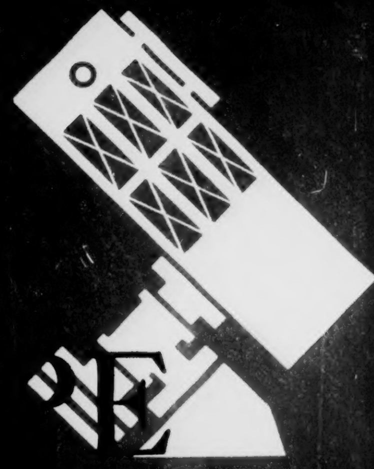

MEETINGS IN INDIANA AND MICHIGAN

The 83rd meeting of the American Astronomical Society will be held at the Kirkwood Observatory of the University of Indiana, Bloomington, from Sunday to Wednesday, June 18th to 21st. A session for the teachers' committee is scheduled for Monday, as well as regular sessions for papers. There will be a trip to the Link Observatory on Tuesday, and the society dinner closes the program on Wednesday evening.

At Bloomington there will be special meetings of the executive committee and members of the United States section of the International Astronomical Union, to discuss resolutions and proposals for the 1951 meeting of the IAU in Leningrad.

Members of the society have been invited by the University of Michigan to participate in the dedication of the Heber D. Curtis telescope following the Bloomington meeting. This program will open Thursday evening, June 22nd, in Ann Arbor, with a lecture by Dr. Walter Baade, of Mount Wilson and Palomar Observatories. On Friday a symposium on "The Structure of the Galaxy" will be held, and on Saturday morning the dedication ceremonies will take place.

Dr. Baade will lead off the symposium discussing "The Andromeda Nebula as a Model of Our Own Galaxy." Dr. Nicholas U. Mayall, Lick Observatory, will present a "Comparison of Rotational Motions Observed in the Galaxy and in the Spirals Messier 31 and 33." Dr. R. Minkowski, Mount Wilson and Palomar Observatories, will discuss "The Galactic Distribution of Planetary Nebulae," and Dr. W. W. Morgan, Yerkes Observatory, will speak on "Spectroscopic Absolute Magnitudes and Parallaxes from Objective Prism Plates."

Two astronomers from Warner and Swasey Observatory, Drs. J. J. Nassau and Sidney W. McCuskey, will describe, respectively, "The Distribution of Early-Type Stars of High Luminosity Near the Galactic Plane," and "Recent Studies of the Stellar Luminosity Function." Two Michigan astronomers, Drs. Freeman D. Miller and Karl G. Henize, are to speak on "Utilization of Faint-Star Counts at Intermediate Latitudes in the Study of Galactic Structure," and "Hydrogen Emission Objects in the Large and Small Magellanic Clouds," respectively.

The director of the Stockholm Observatory and president of the International Astronomical Union, Dr. Bertil Lindblad, will give a feature symposium paper entitled, "On the Dynamical Interpretation of the Velocity Distribution and of Structural Details in the Galaxy." Following this, Dr. A. N. Vyssotsky, of Leander McCormick Observatory, will discuss "Some Features of Galactic Structure Revealed by Stellar Motions." Dr. Harlow Shapley, director of Harvard College Observatory, will preside at the symposium and describe his own work, "On the Relation of the Magellanic Clouds to the Galaxy."

Dr. Leo Goldberg, director of the University of Michigan Observatory, will preside at the dedication ceremonies, in the Lydia Mendelssohn Theatre, 10 o'clock in the morning, June 24th. Among the speakers, Dr. Joel Stebbins, of Lick Observatory, will give an account of "Heber D. Curtis and the Michigan Telescope." In the afternoon there will be a tour of inspection to the Portage Lake Observatory (see *Sky and Telescope*, February, 1950).

SKY and TELESCOPE

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CHARLES A. FEDERER, JR., *Editor;* HELEN S. FEDERER, *Managing Editor*

312,000 OBSERVATIONS

Currently off the press are 16 numbers of Volume 115 of the *Annals* of Harvard College Observatory, representing the work of Cecilia Payne-Gaposchkin and Sergei Gaposchkin on the variables in 16 Milton Bureau variable star fields. The 16 fields contain 475 variable stars on which an aggregate of nearly 312,000 observations were made on the patrol plates in Harvard's photographic library. These observations were all carefully analyzed, and the authors give adequate data on the light curves of the regular periodic variables and much useful data on the others. The fields represented fall in two zones, one between $+15°$ and $-15°$, the other from $-15°$ to $-45°$.

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JUNE, 1950

CONTENTS

COVER: In two ways, these pictures illustrate the parallax and proper motion of Barnard's star. At three epochs in a year the three fields represented by the left-hand portion were photographed with the Sproul Observatory refractor. Barnard's star (lower left) shows displacement both east-west (parallax) and south-north (proper motion) compared to the two background stars in the upper right. In the right-hand part the same fields are superimposed, again illustrating the displacement of Barnard's star in two directions. Variations in the apparent sizes of the images are spurious, resulting from the reproduction process. Sproul Observatory photographs. (See page 183.)

BACK COVER: The moon, between first quarter and full, photographed with the 36-inch refractor of the Lick Observatory, Mt. Hamilton, Calif. South is at the top.

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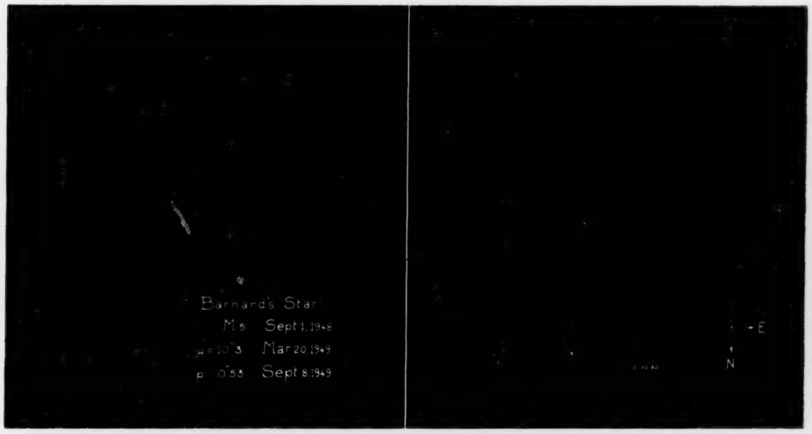
The Parallax and Proper Motion of Barnard's Star

By Peter van de Kamp and Edwin W. Dennison
Sproul Observatory, Swarthmore College

BARNARD'S STAR is notable for its large proper motion and parallax. The first changes the star's position by 10.3 seconds of arc each year in a direction of 356° across the sky; the second amounts to 0.53 second of arc and is equivalent to a distance from the earth of nearly two parsecs or 6.1 light-years. The 1950 position of Barnard's star is $17^h\ 55^m.3$, $+\ 4°\ 29'$, in the constellation of Ophiuchus.

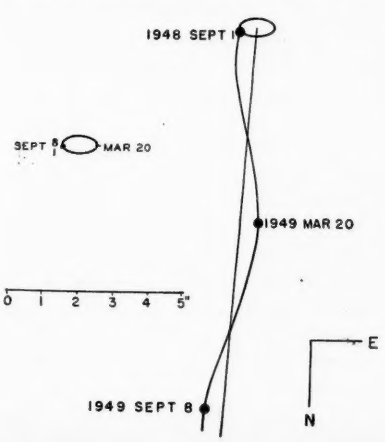
An ideal opportunity to demonstrate annual parallax by direct visual inspection is afforded by photographs taken with a long-focus refractor, such as the Sproul Observatory's 24-inch visual telescope. This instrument has a focal length of 10.93 meters (36 feet), and has therefore a scale value of $1'' = 0.053$ mm. at the focal plane. The size of a good star image is less than 0.100 mm., and therefore it is easily possible to *see* the parallactic displacement on plates taken with this telescope.



Print A (left) and Print B (right) show four stars in addition to Barnard's. Variations in apparent star brightness are not real, resulting from the reproduction process. The scale is nearly 60" = 1 cm., about three times that of the original photographs and about one sixth that of the front cover.

Photographs were recently taken of the region containing Barnard's star at three successive epochs of extreme parallactic displacement, separated by approximately half a year each. The brightness of Barnard's star, apparent magnitude 9.7, was reduced by two magnitudes by a rotating sector to provide approximate equality with the background stars.

Print A shows the three photographs, with a slight south-north shift between the corresponding star images. Four of the sets of images are of "fixed" background stars; the star nearest the left is Barnard's star. Its large proper motion is revealed by the greater spread of the images in the direction south-north. The parallactic displacement is shown by the fact that its central image is slightly shifted to the right; this represents the difference in the direction to Barnard's star as seen from opposite parts of the earth's orbit, that is, from the ends of a baseline 300 million kilometers long.



In Print B the three photographs have been superimposed. The "fixed" stars each give one image, whereas Barnard's star gives three separate images, each corresponding to one of the three positions marked on the diagram, where the scale is also shown. This print shows in a simple, direct way the phenomena of both proper motion and annual parallax. The upper left portions of prints A and B are shown considerably enlarged on the front cover.

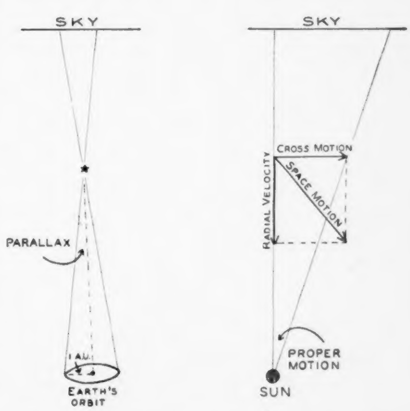
The scale in the diagram may be used to check the more than 10-second displacement of Barnard's star, almost south-north, caused by the proper motion. The displacement east-west, slightly over one second, is due to annual parallax, but is twice the normally expressed value of the parallax, which is based on one astronomical unit. In other words, the photographs show the apparent displacement caused by the earth's motion from one end to the other of a *diameter* of its nearly circular orbit, whereas parallax is always stated as based on the *radius* of the orbit.

Actually, the annual parallax causes a star to appear to trace a small ellipse on the sky, as shown in the diagram. The combination of the star's proper motion with respect to the sun and the parallactic ellipse yields the sinuous geocentric path across the sky, on which the three observed positions are marked.

Parallax and proper motion are both angles, the latter nearly 20 times larger than the former in this case. This means that Barnard's star has a cross motion or tangential velocity (at right angles to the line of sight) of nearly 20 astronomical units per year, which may also be expressed as about 92 kilometers per second.

The other component of a star's space motion *with respect to the sun* is its radial velocity. Spectroscopic observations establish that Barnard's star has a motion of approach of 110 kilometers per second. The resultant of the cross motion and the radial velocity (computed as the hypotenuse of a right triangle) is about 143 kilometers per second, an unusually high velocity even for a dwarf star.

Barnard's star is a red dwarf of spectral type *M*5. It has an absolute visual magnitude of 13.3, corresponding to an intrinsic luminosity only 0.00048 that of the sun. It is the next nearest known star to the sun after the system of Alpha Centauri.



The principle of parallax is illustrated at the left. Space motion is the resultant of cross motion and radial velocity, as shown on the right.

NEWS NOTES

By Dorrit Hoffleit

NOVA OR SUPERNOVA?

On spectrum plates taken March 15th and 20th with the large Schmidt telescope and 26-inch prism at Tonanzintla, Mexico, Dr. Guillermo Haro, of the observatory at Tacubaya, discovered a new star of apparent magnitude 14.5 in the spiral galaxy M83 in Hydra. The nova is located 1′ 45″ west of the nucleus of the galaxy.

The distance of this galaxy is over two million light-years, so the new star must have been of absolute magnitude about −10.3 at the time of discovery. Most ordinary novae at maximum brightness reach only about −5.5 to −7.0. Supernovae, on the other hand, are much brighter, becoming −12 to nearly −17. What, then, shall we call this star?

It may already have been fading when first seen and thus have been brighter before that time. Yet it is curious that another such star has appeared in this same galaxy; it was discovered in 1923 by C. O. Lampland, of the Lowell Observatory. That star, too, had an intermediate magnitude, though it also could have been brighter before it was first seen. Only one other possible supernova had a similar intermediate magnitude, SS Ursae Majoris, whose known light curve is quite different from the average. It was slightly fainter than 13th magnitude when discovered in 1909, and it remained that bright for nearly 80 days, whereas most supernovae discovered near maximum fade some four magnitudes in that time.

The first known extragalactic supernova was observed in the Andromeda spiral in 1885. Since that time more than 40 such stars have been discovered. Ordinary novae are much more numerous, in both the Milky Way system and other galaxies.

AROUND THE WORLD IN A TENTH OF A SECOND

From Annapolis, Md., radio signals have been sent to the National Bureau of Standards station 50 miles away at Sterling, Va., but by the *longest* instead of the shortest route. Traveling all the way around the earth, the radio waves arrived in Virginia a little over 1/10 second after they had been transmitted. This is as it should be if radio waves travel with approximately the velocity of light, 186,000 miles a second. The signals used had a frequency of 18 kilocycles, corresponding to a wave length of approximately 10 miles.

Science Service reports some significant results of this experiment, which has been in progress for some time. During the winter months, when these tests were conducted, the delayed received signal was visible on an oscilloscope all day. At sunset, however, the received signal showed a striking peak intensity. This is explained by the fact that such low-frequency waves are severely attenuated when they pass through a sunset zone. All of the waves throughout the day do pass through a sunset zone somewhere in the world, except that those sent when sunset occurs at the transmitter and receiver "avoid" such attenuation and remain strong.

In going around the earth, these waves are either reflected back and forth many times between the earth's surface and the ionospheric layers of the atmosphere, or they curve gradually in the "wave guides" formed by the concentric spherical surfaces of the earth and the ionosphere. Within the limits of the observed data, either explanation may be accepted to explain this long-distance transmission.

SUNSPOT DATA

Observational data on sunspots formerly published in the *Monthly Weather Review*, such as the positions, areas, and counts of spots, are now being published in a new series of circulars issued by the United States Naval Observatory. The measurements for these tables are being carried out at the Naval Observatory from plates secured either at Washington or at the Mount Wilson Observatory. *Circulars* 3 and 4, dated November 15 and 16, 1949, respectively, give the sunspot data for January through July, 1948, by Lucy T. Day.

In the CURRENT JOURNALS

THE ENERGY OF THE SUN, by Dinsmore Alter, *Griffith Observer*, April, 1950. As late as 1795, Sir William Herschel, greatest authority of the time, still believed the sun to be a huge planet — cool in the interior. This article delineates the rapid progress of knowledge since then.

PSYCHOANALYZING THE FLYING SAUCERS, *Science Digest*, May, 1950; condensed from *Air Force*, February, 1950 (official journal of the Air Force Association). A discussion of 11 things that might be "saucers," including several astronomical bodies.

FATHER SECCHI AND STELLAR SPECTRA, by Martin F. McCarthy, S.J., *Popular Astronomy*, April, 1950. "When the history of the early days of astrophysics, astronomy's newest science, is written, one name which will figure prominently in its pages will be that of Father Angelo Secchi."

METEOROLOGICAL ASPECTS OF RADIO PROPAGATION, by Theodore W. Gibson, Jr., *Weatherwise*, April, 1950. A temperature or humidity duct in the atmosphere can affect microwave and television signals in a manner similar to the effect on radio waves in the ionosphere.

NIGHT-SKY STUDIES

High on the top of an extinct volcano in the Mojave Desert, astronomers associated with the Naval Ordnance Test Station at Inyokern have set up a unique photoelectric photometer for studying the light of the night sky. The photocell is used with a 4-inch lens of four inches focal length, with diaphragms for sky areas measuring two by 10 degrees. Two filters are used alternately, each transmitting a spectral band of about 150 angstroms.

The instrument sweeps the sky along any vertical circle from horizon through the zenith to the opposite horizon; it then shifts 22½ degrees in azimuth for another sweep. A sky survey of eight sweeps requires 32 minutes. The filters are alternated about every four or five seconds, one transmitting wave lengths containing a strong emission line, the other a neighboring region not including emission lines. It is then possible to ascertain at what heights above the earth's surface the elements occur that are responsible for the emission lines in the night-sky spectrum.

Dr. F. E. Roach, of Inyokern, and Dr. Daniel Barbier, of the Institut d'Astrophysique, Paris, in papers in the *Transactions* of the American Geophysical Union, reported that the atoms producing the green oxygen line occur at 110 kilometers, while sodium D lines are produced at an average height of 310 kilometers.

Strong sodium emissions occur near the azimuth of the sun long after the sun is 18 degrees below the horizon (the end of astronomical twilight); these emissions were detectable even when the sun was nearly 40 degrees below the horizon. Presumably excited to shine by grazing rays from the sun, these sodium atoms would in some cases have to be as high as 1,000 kilometers above the earth's surface. It may be that the density of the atmosphere diminishes more slowly with height than hitherto supposed. Another possibility is that the sodium is swept up from interplanetary space by the earth, but the density of about one atom per cubic centimeter implied by the observations is exceedingly high compared with the supposed density of interplanetary space.

WINDOWS HALF A FOOT THICK

Two optical glass windows, each 50 inches in diameter and half a foot thick, have been recently finished by Tinsley Laboratories, of Berkeley, Calif., to be used in the world's largest supersonic wind tunnel at Ames Laboratory, Moffett Field, Calif. The original blanks weighed 3,000 pounds apiece; they are valued at $30,000 each. These windows are needed to permit schlieren photography of the formation of shock waves by models of high-speed airplanes and missiles.

Notation of the Atmospheric Strata and Their Characteristics

	Spheres	Layers	Height in km approximately	Temperature (°C)				Prevailing wind direction
				at lower boundary	at upper boundary	Extreme values	Lapse rate in °C/100 m	
Outer Atmosphere	Exosphere		above 800	?	?	2000?		
Inner Atmosphere	Ionosphere	Atomic layer	400–800	?	?	1200?		
		F layer	150–400	?	?	+60 to +1000	positive	West
		E layer	80–150	−70	+50	+80 to +100	positive	
	Stratosphere	Upper mixing layer	50–80	+50	−70	−80 to +70	appr. 0.4	Winter: W Summer: E
		Warm layer	35–50	−50	+50	−60 to +80	−0.4 to 0	
		Isothermal layer	12–35	−55	−50	−45 to −65	−0.1 to +0.1	
	Troposphere	Tropopause layer	8–12	−40	−55	−35 to −80	−1 to +1	
		Advection layer	2– 8	+10	−40	+20 to −45	−1 to 0*	
		Ground layer	0.002– 2	—	—	−40 to +40	−10 to +3	West
		Bottom layer	0–0.002	—	—	−50 to +80	—	

* Disregarding inversions.

This is a portion of a table of proposed nomenclature of the earth's atmosphere drawn up by Flohn and Penndorf. The numerical quantities are valid for average conditions at latitudes 45° to 55° north. Courtesy, "Bulletin" of the American Meteorological Society.

ATMOSPHERIC TERMINOLOGY

Now that a great many scientists besides meteorologists are concerned with the structure of the atmosphere, both at low and at very high altitudes, all of them might well start giving the same names the same meanings, whether they be weather experts, pilots, rocketeers, radio experts, or meteoriticists.

"Unnecessary controversies have arisen between several authors and schools because the same word has been used for different layers," state H. Flohn and R. Penndorf in their article, "The Stratification of the Atmosphere," in the March issue of the *Bulletin* of the American Meteorological Society. They invite discussion of the terminology they propose, based generally on the data in the table from their article reproduced above.

The atmosphere is considered divided into an inner and an outer portion; from the latter, particles may escape from the gravitational or magnetic field of the earth. The inner atmosphere is divided into three spheres, and each sphere in turn into several layers. A layer is characterized by its uniform thermal structure. The word region is reserved for a subdivision of a layer.

THE COMPOSITION OF THE UNIVERSE

In *Physics Today* for April, Dr. Harrison Brown, University of Chicago chemist, summarizes the evidence for the belief that the chemical composition of the universe is everywhere pretty much the same. A single meteorite sample may, of course, not seem very representative of what we know about the crust of the earth or the atmosphere of the sun. There appears to be a deficiency of hydrogen relative to oxygen in the surface layers of the earth, when compared with the ratio of more than a thousand to one for hydrogen to oxygen in the stars. This and the apparently different compositions of the other planets can readily be accounted for by their positions relative to the sun, according to Dr. Brown.

On the assumption that the solar system is derived from one condensing primordial mass, planets formed at various distances would show different compositions depending on which elements would solidify at varying distances from the center of the sun; this would depend also on whether a particular planet had a mass large enough to hold an atmosphere made up of the lighter elements, as in the cases of Jupiter and Saturn.

Considering the minuteness of the sample of the chemical constituents of the universe that is available for either direct chemical analysis or spectroscopic studies, and the vastly different appearances of the spectra of various classes of stars, the convincing proof of the sameness throughout the universe is astonishing even to those who have long predicted it.

NEW INDIAN OBSERVATORY

Kodaikanal Observatory is to have a city station at Madras. A 20-inch Grubb reflector has been donated by H. H. Maharaja Kumarsinhji, of Bhavnagar. Construction of a dome has been approved by the government. At the same time tests on seeing both day and night are under way to determine the suitability of Kodaikanal itself for the installation of coronagraph equipment and a larger telescope.

Since the 20-inch will be among the largest telescopes in India, it seems a pity that it should be located in a large city.

PROXIMA CENTAURI AS A FLARE STAR

Dr. A. D. Thackeray, of the Radcliffe Observatory at Pretoria, reports briefly in the *Monthly Notes* of the Astronomical Society of South Africa on some spectrum peculiarities in our nearest known neighboring star. Nine spectrograms were obtained between June and August, 1949. On five of them emission lines of hydrogen and calcium appear, as well as the usual absorption features of this late *M*-type dwarf. The bright (emission) lines vary in intensity; on July 4th they showed remarkably strongly, and Thackeray suggests that Proxima may have "flared" on that occasion.

MORE ON A DISTANT PLANET

The history of astronomy reveals again and again that there are indeed few really new discoveries. Last month (page 165) we discussed the discovery by Karl Schuette, of Munich, of a family of comets that very strongly suggests there must be a planet beyond the orbit of Pluto, at about 77 astronomical units from the sun. Schuette had already discussed this matter in *Popular Astronomy* more than a year ago. Now Walter Scott Houston, of Milwaukee, points out that William H. Pickering had similarly predicted such a planet many years ago.

In *Popular Astronomy* in 1928, Pickering had, indeed, made this prediction, before the discovery of Pluto. In fact, having found that only four comets had aphelion distances clustering about the distance of Pluto (called Planet *O*), while 16 had aphelia between 75 and 80 astronomical units, Pickering predicted that their associated Planet *P* should be more massive and important than Planet *O*. He also had previously predicted the existence of Planet *P* from planetary perturbations, and in 1931 published a provisional orbit for it and indicated a search area. He believed this to be the third largest planet in the solar system, and expressed his displeasure at the prior discovery of Pluto thus, discussing Planet *P*:

"When I first recognized its importance, from its comets, some twenty years ago, I mentally reserved for it the name Pluto as the son of Saturn, and the brother of Jupiter and Neptune, but unfortunately that small object planet *O* came round and perturbed Neptune some ten years before the leisurely *P* arrived and perturbed Uranus, and so received the name. Pluto should be renamed Loki, the god of thieves! A suitable name for *P* will now indeed be difficult to find when that planet is discovered."

We suggest that if Planet *P* is ever found it be given the name Loki for having stolen so many comets!

HENRY DRAPER MEDAL

At its annual dinner on April 25th, the National Academy of Sciences conferred the Henry Draper gold medal for 1949 on Dr. Otto Struve, of Yerkes and McDonald Observatories, in recognition of his contributions to astronomical physics. Presentation of the medal was made by Dr. Alfred N. Richards, president of the academy, after the citation had been read by Dr. Paul W. Merrill, of the Mount Wilson and Palomar Observatories.

Visual Double Stars-I

By Otto Struve, *Yerkes and McDonald Observatories*

DURING the recent New York meeting of the American Association for the Advancement of Science, Raymond H. Wilson, Jr., announced an important discovery which focuses the attention of the astronomers upon the old problem of the visual binaries. Wilson has experimented with an interferometer and has used it in order to measure the separations and position angles of a number of close binaries. His program included a list of stars which J. A. Hynek had previously catalogued as possessing spectroscopic features normally associated with two different types of stars. However, these stars with composite spectra were not formerly known to be visual binaries, and it was simply a surmise that the conflicting spectroscopic features in each case belong to two different stars which are too close to be resolved with existing telescopes.

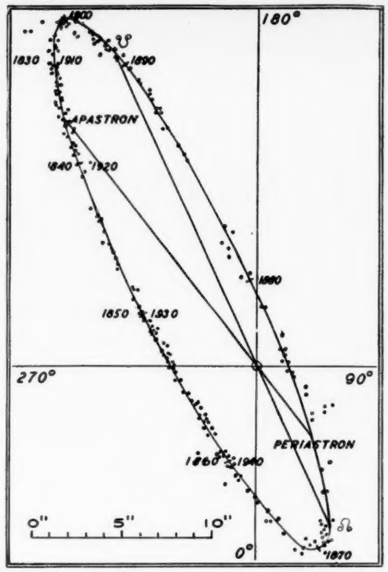
The star 31 Cygni is known as No. 13554 in R. G. Aitken's great catalogue of double stars. One of the components of this wide double star was listed by Miss A. J. Cannon in the *Henry Draper Catalogue* as possessing a spectrum composite of the characteristics of spectral types *B*8 and *K*0. But neither Aitken nor any other visual double star observer had ever detected any trace of duplicity in this, the brighter component of the Aitken pair. With the help of a Fizeau-Michelson interferometer in front of the 18-inch refracting telescope of the Flower Observatory, University of Pennsylvania, Wilson found in 1949 that there are in reality two very close stars whose distance apart is 0.06 second of arc in position angle 140 degrees.

After he had made this observation, however, he learned that this component of 31 Cygni was already known as a spectroscopic binary having a period of about 10½ years. Spectroscopic observations making use of the Doppler principle had been obtained by W. H. Christie at Mount Wilson, by M. Tremblot in France and, most recently, by Miss Julie Vinter Hansen at the Lick Observatory. All these observers agree that the spectroscopic orbit is slightly eccentric, and that the orbital velocities of the *K*-type and *B*-type components are approximately 13 and 17 kilometers per second, the *K* star being the more massive of the two. This last fact means that the *K* star should have greater intrinsic luminosity than the *B* star, and therefore that in the photographic region of the spectrum the total light of the *K* component should not be very different from that of the *B* component. As we shall see, this near-equality made more favorable the probability of observing the star as a visual binary by means of the interferometer.

Wilson has pointed out that Miss Vinter Hansen's spectroscopic observations virtually predicted his own discovery, since with a spectroscopic parallax of 0.005 second of arc the maximum angular separation of the binary would have been approximately 0.07 second, a value which, she stated, was below the visual limit of resolution of the 36-inch Lick refractor, but which has proved to be entirely within the limit of resolution of such a simple instrument as a Fizeau-Michelson interferometer attached to an 18-inch telescope. Moreover, the greatest separation of the two stars should have occurred about in 1949 — exactly the time when Wilson observed the pair.

After Wilson's discovery was announced, D. B. McLaughlin at the University of Michigan re-examined his spectrograms of 31 Cygni and noticed that in July, 1941, there occurred an atmospheric eclipse of the hotter star by the cooler one. During the interval when the *B* component was obscured by the *K* star, the composite features of the spectrum vanished and the calcium lines stood out as strong and sharp features, as they do in an ordinary spectrum of a *K*-type star. This observation also agrees with Miss Vinter Hansen's orbit. The next eclipse is predicted by McLaughlin to take place on December 29, 1951.

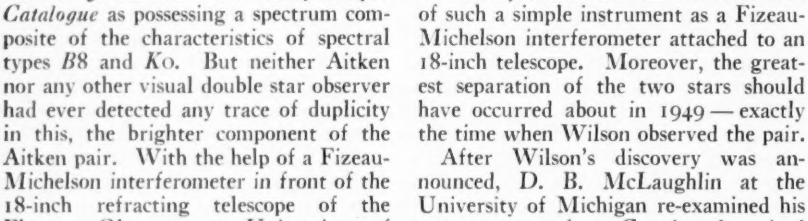
Wilson's remarkable observations prove again the superior power of the interferometer when applied to the



The orbit of the visual double star Alpha Centauri for 110 years, after Finsen. Periastron is where the stars are nearest each other; apastron is where they are farthest apart. The dots represent individual observations. The line of nodes shows where the orbit cuts the sky.

measurement of certain visual double stars. In 1940, Dr. Wilson described his method in the October issue of The SKY, and this is not the place to review all the optical details involved. There are, however, a few points that sometimes have been ignored in connection with the use of an interferometer. The approximate theory was given long ago, and the illuminating account of it by A. A. Michelson in his book, *Light Waves and Their Uses,* may still be regarded as standard. But observers have sometimes complained that their work was adversely affected by two important circumstances. The first is that the stars to be observed must be very bright, since the Michelson arrangement uses two narrow vertical slits over the telescope objective and is very inefficient in light. The second difficulty arises from the fact that the two components must be of approximately the same brightness, since otherwise the interference fringes do not completely disappear when the light maxima of the fringes of one star coincide with the dark minima of the fringes of the other star.

Fig. 1a shows schematically the arrangement of the Michelson interferometer with two slits. The fringes produced by the two apertures *M* and *N* in the focal plane *F* are observed with a high-power eyepiece. If we have only a single star, we obtain a distribution of light shown by the continuous curve of Fig. 1b. If the star is double, we observe in the eyepiece a second set of fringes indicated by the dotted line. The measurement consists in changing the



1908 1915 1920

Photographs of the visual double star Krueger 60 (upper left), by Barnard at Yerkes Observatory. Note the revolution of the fainter component around its primary in 12 years. Krueger 60 is in Cepheus.

distance between the apertures M and N. In doing so we alter the relative positions of the fringes and we can make them look as is shown in Fig. 1c. In this arrangement the dark fringes of one star are filled in by the bright fringes of the other star. This occurs when the distance between the two apertures, s, is given approximately by the expression,

$$\theta = \tfrac{1}{2} (\lambda/s),$$

where θ is the angular separation of the two stars and λ is the wave length of light. The distance between the apertures can be directly measured at the objective of the telescope, and the wave length can be taken to be that of ordinary visual light, or about 1/50,000 of an inch. Hence, if in the course of observing a double star we find that the fringes disappear when the separation between the apertures is 10 inches, the angle θ = 1/1,000,000 radian, or approximately 0.2 second of arc. The method can be used even when the angular separation is much less than θ, as was shown in 1920 by J. A. Anderson.

In order to appreciate the great resolving power of the interferometer we can compare this value with the theoretical resolution of an ordinary telescope. It is given by the expression,

$$d = 1.2\lambda/a$$

where a is the aperture of the telescope. Thus, a 10-inch could completely resolve two stars with a separation of the order of 0.48 second — more than twice the value given by the interferometer. We shall see in a minute that there is an additional gain in using the interferometer.

The disadvantage of the inefficiency in light has been removed by Wilson through the use of relatively wide apertures. An even better method has been advocated by A. Danjon, who has made use of an optical device called a Jamin compensator which replaces the Michelson slits in front of the objective. This method is simple in principle, but it requires a considerable amount of mathematics to develop the necessary formulae.

The disadvantage of requiring double stars with approximately equal components cannot be overcome. But it is more than compensated for by a remarkable lack of sensitivity of the whole procedure with respect to the greatest enemy of the astronomer, namely, poor seeing. Observers noticed long ago that the interferometer fringes are much less influenced by bad seeing than are direct images of the stars. Wilson attributed this phenomenon to the fact that the light which is used in forming the interferometer fringes comes from two relatively small areas of the telescope objective; hence the effect of seeing should be more nearly that which corresponds to a small-aperture telescope. On the other hand, when we observe the star image with the full aperture of the objective we see the fluctuation of the image formed by the entire aperture.

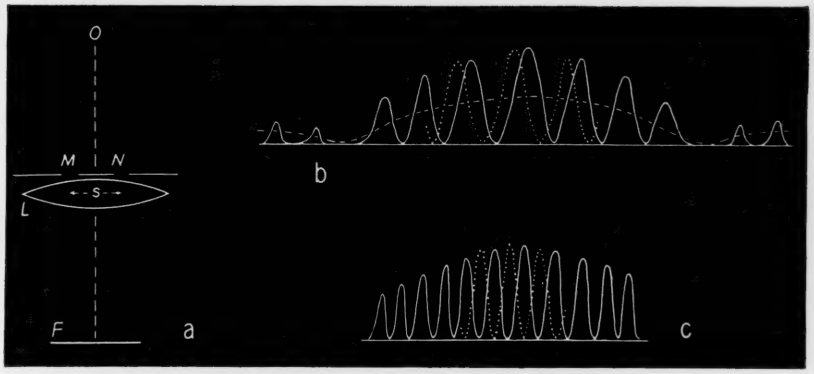


Fig. 1. In part a (left), L is the lens of the telescope, F is its focal plane, M and N are two vertical slits, at right angles to the plane of the paper, through which the object O is observed. A single star or a single bright wire produces the solid-curve pattern of part b, with a second pattern (dotted) if the source is double. In part c is shown the method of measurement. The distance s between M and N is increased, which causes the fringes to become narrower until the bright fringes of the second star fill in the dark fringes of the first star.

But this is only a part of the story. Danjon has shown in his monograph published in Volume 3 of the *Annales* of the Observatory of Strasbourg that the irregular motions of the diffraction fringes are actually about five times smaller than the corresponding excursions of the normal stellar images. This is due to the fact that the fringes are affected only by the differences in path of two beams of light, and this varies considerably less than the position in the focal plane of each individual beam.

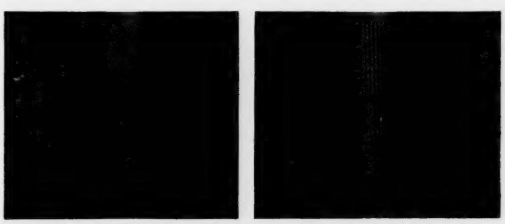
Michelson has given an interesting photographic illustration of the diffraction phenomena observed in the case of a luminous straight wire which he used in place of a star. Fig. 2a shows the image of such a light source produced by a single slit. When two slits are used, the central bright image is broken up into the numerous narrow fringes shown in Fig. 2b. This corresponds to the continuous line in Fig. 1b and 1c. If we now imagine that, instead of observing a single bright wire, we have two parallel wires close together, we must imagine that another set of fringes is superposed over that of Fig. 2b. When these two sets of fringes are far apart, we could measure their distances with the micrometer and probably achieve a greater precision than could be done by measuring two direct images of the type shown in Fig. 2a. But if the sources are very close, it is much easier gradually to separate the slits over the objective, thereby rendering the distances between successive dark fringes smaller and smaller, and finally achieving the form shown in Fig. 1c, when the fringes disappear from sight.

There is no fundamental difference between the straight incandescent wires used by Michelson and the stellar images observed in astronomy. The method has been used successfully by Anderson and P. W. Merrill at Mount Wilson, G. Van Biesbroeck at Yerkes, H. M. Jeffers at Lick, and M. Maggini in Italy. It will never replace the filar micrometer or the photographic plate, but it should be used extensively for those double stars which are just below the resolving power of the best available telescopes and which consist of two approximately equal components.

The question often arises whether it is still necessary to continue systematic visual observations of double stars. Many thousands of these objects are known, and have been catalogued by Aitken and by R. T. Innes; and many millions of measurements have been made during the past 200 years. It is unnecessary to describe in detail the information these results have provided. The double stars give us our only knowledge of stellar masses. They also have given us confidence to extend into the stellar universe the law of gravitation that had been found to operate in the solar system.

(*To be concluded*)

Fig. 2. Michelson's examples of the diffraction patterns observed with a single slit (2a, left) and with a pair of slits (2b, right). The sharp, narrow fringes of 2b correspond to the solid-curve pattern of Fig. 1b and 1c.



LETTERS

A. J. Symonds, of Dunedin, New Zealand, kept his camera fixed during this time exposure. Therefore the crescent moon and Venus below it appear as broad streaks. The direction toward the horizon is right to left, opposite to that for objects setting in northern latitudes.

Sir:

The enclosed picture of the crescent moon and Venus was made on December 23rd, from 21:38 to 22:26 (New Zealand standard time). Venus set at 21:56; the moon's southern cusp disappeared behind the tree tops at 22:20, and the northern cusp went down three minutes later, behind the house.

I originally started photographing the sky to catch meteors, but so far have had no success. Although you may see them frequently, they are pretty elusive photographically, aren't they?

Another picture enclosed shows the region of the south celestial pole, photographed from 20:50 to 22:20 NZST on March 4th last year.

My brother has, I believe, corresponded with you on various occasions. He lives in Hastings, and is a very keen amateur astronomer.

A. J. SYMONDS
P. O. Box 33
Dunedin, New Zealand

Sir:

A few weeks ago I had some X-rays taken and I noticed that the doctor was wearing goggles. He told me that he put them on some time before the fluoroscopic examination so that he could engage in normal activities while his eyes were becoming dark-adapted, the goggles being designed for the purpose. I thought that I would like to try some for astronomy, so I got a pair (Willson Monogoggles, $3.00 postpaid) from the General Electric X-ray Corporation in Boston, and I have found them useful. I wonder if any astronomers are in the habit of using them.

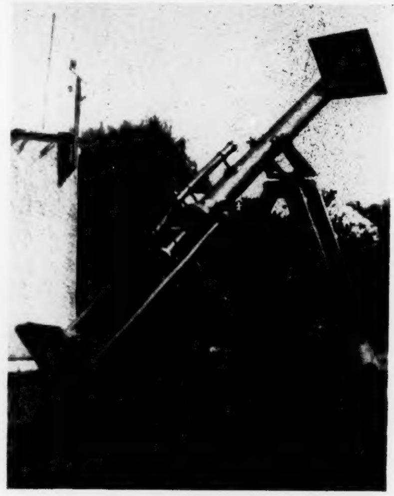
I can read or do anything that does not require the recognition of colors, for everything looks red when one wears the goggles. After having them on for 15 minutes to about half an hour, I can go outside and see the stars quite nicely; they are especially helpful slipped down over the eyes when one enters a lighted room to look at a chart. They can be worn over spectacles, and slipped up on one's forehead when they are not in use.

Not long ago I wanted to look at some of the stars in Scorpius, in the early morning, so that I wouldn't have to wait until summer, and I wore my goggles while I was putting on a few clothes, so that my eyes remained probably about the same as they had been during the night.

HENRY S. SHAW
R.F.D. 1, Box 294-B
Westbrook, Me.

Sir:

I was interested in the cover photograph on the July, 1949, issue of **Sky and Telescope,** showing the projection of an image of the sun. I enclose a photograph of my 3-inch Dollond refractor fitted for the projection method of observing sunspots. The attachment was made up from a suggestion in the 1948 **Observer's Handbook** of the New Zealand Astronomical Society, and proved quite successful. With this equipment I have taken some 8-mm. Kodachrome shots, and the sunspots photographed excellently, better than in black and white.



Roy V. Symonds' 3-inch refractor fitted for sunspot observing.

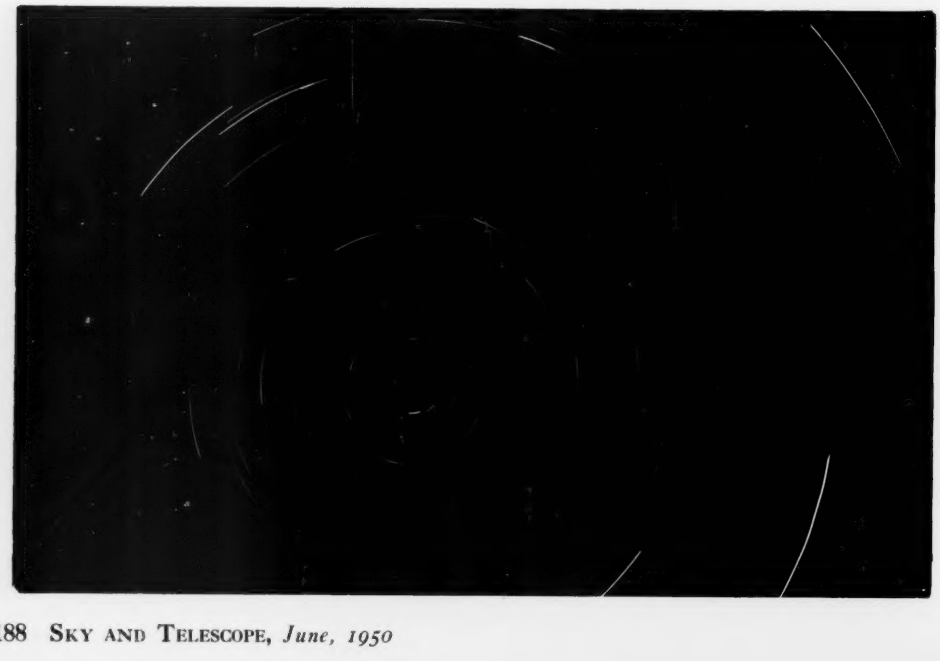
ROY V. SYMONDS
P. O. Box 64
Hastings, New Zealand

Sir:

At 13:00 UT, March 30th, when I started to "shoot the sun" for my daily sunspot count, there was a remarkable display of halos and sundogs. Therefore I decided to get a log of the show to see just what took place.

About half an hour after the start of the phenomenon, two halos were visible, with a circumzenithal arc and a similar arc below near the horizon. These were bright and colored, as was the entire outer ring against which they lay. Their length was about 15 degrees, and their chordal depth about four degrees. There were also two sundogs, situated about midway

(Continued on page 191)



The south circumpolar stars, photographed with a 1½-hour exposure by A. J. Symonds. To identify the stars make a tracing plotting only one end of each star trail, larger dots to represent brighter stars. Omicron Octantis is the bright, short trail just below the south celestial pole, at the center of the trails. Gamma Hydri is at the top right; Beta Hydri at bottom right; stars in Chamaeleon are at upper left. Orange and red stars photographed relatively faint and may not appear of the magnitudes shown for them on ordinary star charts.

THE ROMAN CALENDAR

By Robert R. Gates

THE FIRST ATTEMPTS of the Romans at reckoning time by a calendar were very crude. Originally, they divided the year into 10 months, the number of days of which was anything between 20 and 35. The only rule was that the number of days in the year be kept to 360. This method continued to the time of Numa Pompilius, the second king of Rome.

It is generally believed that Numa added the months Ianuarius and Februarius to the end of the year. In addition, he calculated the difference between the lunar year and the solar year to be 11 days. To remedy this incongruity, he doubled the 11 days and inserted them as an intercalary month, called Mercedonius, every other year after Februarius.

Later, Numa altered the order of the months, placing Martius, then the first, in the third place and Ianuarius first. The order of the months with the number of days in each was thus:

1.	Ianuarius	29	7.	Quintilis	31
2.	Februarius	28	8.	Sextilis	29
3.	Martius	31	9.	September	29
4.	Aprilis	29	10.	October	31
5.	Maius	31	11.	November	29
6.	Iunius	29	12.	December	29

Some authorities say that Februarius had 29 instead of 28 days. The exact number probably varied a day or two because of the intercalary month. It is also believed by some that throughout Numa's reign Ianuarius and Februarius were at the end of the year. The order above was taken from Clough's *Plutarch*. It will be noticed that six of the months bear numerical names showing their order in the original 10-month calendar.

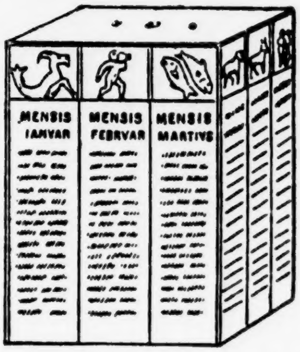
By the time of Julius Caesar, the intercalation of months, under the charge of the pontiffs, had caused the festival days to be altered considerably from their proper places in the year. To correct this, Julius Caesar invited the Greek astronomer Sosigenes to Rome to revise the calendar and to restore the vernal equinox to March. To do this, two months were inserted between November and December, making the year A.U.C. 708 (46 B.C.) contain 14 months. It was often referred to as "the year of confusion."

In 44 B.C. Marcus Antonius changed the name of Quintilis to Iulius in honor of Caesar. Later, Sextilis was changed to Augustus in honor of Augustus Caesar. In imitation, Domitian gave his names, Germanicus and Domitianus, to the following two months, but on his being slain they regained their original names. Had this not been the case, our present calendar would probably not have "September" and "October."

The months of the calendar as finally reformed were thus:

1.	Ianuarius	31	7.	Iulius	31
2.	Februarius	28	8.	Augustus	31
3.	Martius	31	9.	September	30
4.	Aprilis	30	10.	October	31
5.	Maius	31	11.	November	30
6.	Iunius	30	12.	December	31

The first day of the month was called *kalendae* (calends), so named from *calare* — to call. Calends was originally the day on which the pontifex maximus publicly announced the new moon in the Comitia Calata.



A Roman calendar tablet, with the 12 months conveniently arranged on four sides. Note the zodiacal signs.

The 15th day of March, May, July, and October, and the 13th of the other months was called *idus* (ides), the day of the full moon. The name is derived from *iduere* — to divide. Nine days before the ides, that is, the seventh of March, May, July, and October, and the fifth of the other months, occurred the *nonae* (nones or ninths). The Roman dates were always reckoned backward from the calends, nones, or ides, whether in the same month or the preceding, and both dates were always included in the reckoning.

To determine the date in our modern calendar, given the Roman notation: If the given date be calends, add two to the number of days in the preceding month; if nones or ides, add one to the number of the day on which the nones or ides fall. From the number thus obtained subtract the given date, thus:

VIII Kal. Feb. (31 plus 2 minus 8) equals Jan. 25

IV Non. Mar. (7 plus 1 minus 4) equals Mar. 4

IV Id. Sept. (13 plus 1 minus 4) equals Sept. 10.

In leap year the day following VI Kal. Mart. (Feb. 24) was *bis sextum Kal. Mart.*

A. D. V Kal. Apr. would mean *ante diem quintum Kalendas Aprilis* — the fifth day before the calends of April.

The days also bore certain marks. A sign like N and P joined indicated the festival days. F (*fastus*) meant that legal business might be conducted on that day. NF (*nefastus*) meant just the opposite. Days marked C were ones on which the Comitia might meet. Those marked EN were *nefastus* in the morning and evening but *fastus* in the middle of the day.

The year was ordinarily expressed by the names of the consuls in the ablative absolute case. Historians, however, used the number of years after the founding of Rome (A.U.C.—*anno urbis conditae*).

PERMANENT DAYLIGHT SAVING

When a section or municipality adopts the standard time of the zone to the east of it, daylight saving time is in effect. In sections and cities in more than half of the United States this is an annual summertime measure, but the National Geographic Society points out that there is a consistent trend whereby such daylight saving becomes permanent for a certain region.

Thus, by a recent time zone directive, the Interstate Commerce Commission has permanently placed Arizona's northwest corner, about 1/10 of the state's area, on Mountain time instead of on Pacific time. The rest of Arizona has already been on Mountain time. The affected region is about 114 degrees of longitude west of Greenwich. By a peculiar coincidence, at nearly the same time Sarawak, British Borneo, about 114 degrees east of Greenwich, has shifted its standard time by one-half hour, putting it on the same time as other units of British Borneo, which are known as North Borneo and Brunei.

In October, 1918, the ICC first defined the time zone boundaries for the United States. Prior to this the four time zones had been in use by the nation's leading railroads for nearly 35 years. ICC directives averaging one a year since 1919 have concerned changes in the time zone boundaries. It required nine directives to move the line between Eastern and Central time from the center of Ohio in 1919 westward to include the entire state as at present.

In 1922 Detroit, and in 1936 all the Michigan lower peninsula moved from the central to the eastern zone. Other states affected by westward changes have been Kentucky, Virginia, North Carolina, Tennessee, Georgia, Texas, Oklahoma, Kansas, North Dakota, Montana, and Idaho. The eastern, central, and mountain belts now lie three fourths or more to the west of the meridians on which their times are based, giving their western portions permanent daylight saving time. The Pacific zone is almost in balance along the 120th meridian.

Amateur Astronomers

North Central Regional Convention Held at Oshkosh

OVER 30 amateurs traveled an average of 100 miles each to attend the North Central regional convention of the Astronomical League, held April 14-15 in Oshkosh, Wis. Ralph N. Buckstaff, chairman of the region, was host to the group at his observatory and at the Oshkosh Public Museum.

An informal gathering at the Buckstaff Observatory opened the activities on Friday evening. Favorable skies co-operated to provide a full evening of observing with the 16-inch Cassegrainian reflector in one of the observatory domes. A number of globulars and galaxies were inspected, as well as the usual planets and double stars.

At the museum the following morning, many delegates expressed their admiration for the fine exhibits on the history and natural history of the region. A visit later in the day to the nearby Paine Art Center proved equally impressive. An address of welcome by Nils Behncke, director of the museum, and an explanation of the museum's astronomy display by Edward Lundsted, curator, opened the sessions. The papers presented in the morning were devoted principally to the sun and solar observing, while those in the afternoon discussed variable star observing.

Edward P. Baillie, president of the Madison Astronomical Society, discussed possible theories of sunspot formation. Mr. Buckstaff, an avid AAVSO solar observer, presented graphs of sunspot activity during the year. Frederick Haigh, a student at the Oshkosh State Teachers College, pointed out that the auroral maximum occurs one or two years after the sunspot maximum.

An informal luncheon was arranged at the observatory by Mrs. Buckstaff, and the sun was observed with a 5-inch refractor and another telescope.

Among the afternoon papers was one by Roy E. Lee, of the Milwaukee Astronomical Society, in which he discussed the recent light curves of several irregular variables on the AAVSO observing list. Dr. C. M. Huffer, of the Washburn Observatory, showed some of his photoelectric photometer tracings of Algol minima, and described his proposed plans to employ an IBM calculator to redetermine the constants of this binary. A brief review of the photographic variable star techniques at Harvard Observatory was then presented by this reporter.

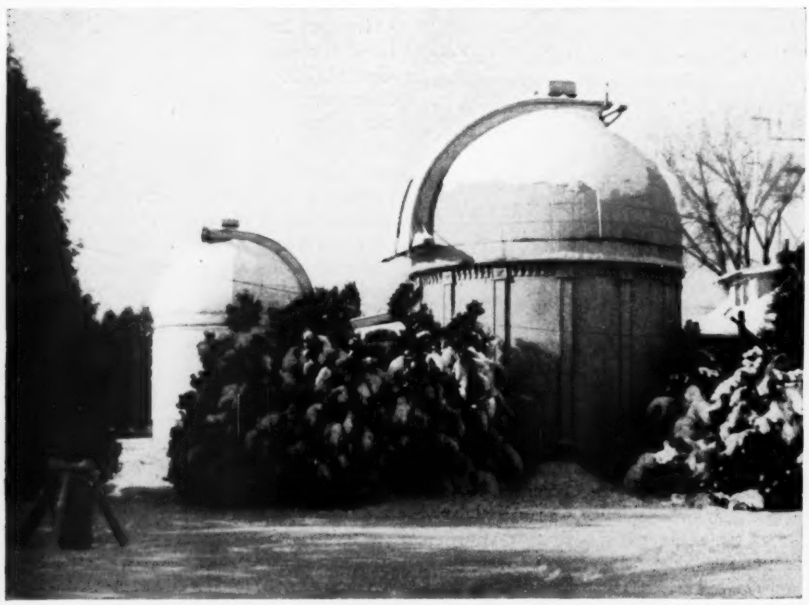
Flare stars were discussed by Edward A. Halbach, director of the Milwaukee society's observatory. Latest information concerning Nova Lacertae 1950 was presented by Elizabeth Wight, regional secretary. Both Luyten's flare star and Nova Lacertae 1950 are available on AAVSO charts. Dr. Huffer kept the convention scientifically sound by injecting an informal critique of the papers in the brief discussion period following each topic.

Mr. Buckstaff, H. B. Porterfield, and Miss Wight were unanimously re-elected chairman, vice-chairman, and secretary-treasurer of the region. Roy L. Dodd was chosen regional representative to the league council.

Reports from the Duluth, Madison, and Milwaukee societies were heard. At Duluth, temperatures this winter ranging to 40 below hindered observing. The Madison Astronomical Society hopes for an expanded observing section. The Milwaukee society has 10-inch, 12-inch, and 13-inch reflectors available for its heavy observing program. A heater system on the 13-inch has eliminated dewing troubles.

The convention closed with a banquet at the Athearn Hotel. Dr. Thornton Page, of Yerkes Observatory, gave an illustrated lecture on the origin of the solar system. He discussed the historic theories of Kant and Laplace, and showed how these have been developed by modern scholars. Discussion and questions followed the lecture, including a lively debate on the meteoritic versus the volcanic origin of lunar craters.

Owen Gingerich
1613 South 8th St.
Goshen, Ind.



The private observatory of Ralph N. Buckstaff, Oshkosh, Wis.

THE BUCKSTAFF OBSERVATORY

TWO TELESCOPES are housed in each of the two domes of the private observatory of Ralph N. Buckstaff, in Oshkosh, Wis., where the 1950 meeting of the North Central region of the Astronomical League was held.

The nine-foot dome contains two Mellish refractors, a 5-inch and a 3-inch, mounted side by side on an equatorial head driven by a synchronous motor. At the eye end of the 5-inch is a revolving metal disk to which may be attached Stonyhurst charts. On these the sun's image is projected to permit measurement of the positions of sunspots. The 3-inch telescope is used for visual observations of the sun's surface, including sunspot counting.

Another 5-inch Mellish refractor is mounted on the tube of a 16-inch Fecker Cassegrainian reflector in a motor-driven 15-foot dome. These instruments are used for the visual study of variable stars and planets. A camera will be placed in the focal plane of the larger telescope to photograph the sun's surface.

This observatory is the official United States Weather Bureau co-operative station for Oshkosh. The weather instruments consist of a tilting-bucket rain gauge, an 8-inch rain gauge, sunshine recorder, anemometer, thermograph, barograph, mercury barometer, wind vane, maximum and minimum thermometers. Five of these instruments are self-recording.

The Buckstaff Observatory library contains about 3,000 books and pamphlets, 1,700 of which are on astronomy and 400 on meteorology.

NEW LEAGUE MEMBER

The Central Missouri Amateur Astronomers, with 34 members on April 15th, has become a member of the Astronomical League. The secretary of the group is Russell C. Maag, 611 Bluff St., Fulton, Mo. The society will be co-host at the mid-central states amateur convention on June 17-18 (see last month's issue, page 167).

EMSLEY W. JOHNSON DIES

The Indiana Astronomical Society has lost its leading member, Emsley W. Johnson, who died in April after a long illness. He was one of the most enthusiastic members of the organization, and had served as its president for many years, a post he held at the time of his death. Several years ago he established the policy of making up the society's program of lectures and meetings annually in advance, a procedure that he remarked recently had done much to increase interest in the meetings. Mr. Johnson, an Indianapolis lawyer, had reached the age of 71.

As a memorial to their late president, Indiana members have decided to donate volumes from their astronomical libraries to the Indianapolis Public Library. Each such book will bear the inscription:

"Donated by . . . . . of the Indiana Astronomical Society in memory of our president, Emsley W. Johnson, Sr., who joined the stars he loved on April 12, 1950."

The Johnson Memorial Astronomical Library starts with some 30 volumes, to which others will be added from time to time to keep the references up to date.

The new president of the Indiana Astronomical Society is Clark B. Hicks, 4053 Ruckle St., Indianapolis. He is a charter member, and was associated with founder Samuel Waters and Mr. Johnson in the formation of the organization.

REGIONAL MEETING AT YAKIMA

The Yakima Amateur Astronomers will be hosts to the annual convention of the Northwest region of the Astronomical League, on Saturday and Sunday, July 29-30, in the Pacific Power and Light Company auditorium in Yakima, Wash. The program will include business sessions, papers by amateurs, a banquet, a public lecture, exhibits of amateur-made instruments, photographs, and promotional material.

The membership of the Northwest region at present includes the Portland Astronomical Society, the Portland Amateur Telescope Makers and Observers, and the Yakima Amateur Astronomers. Astronomy clubs in Spokane and Tacoma will be invited to attend the Yakima convention and to join the Astronomical League.

Edward J. Newman, 324 West Yakima Ave., Yakima, Wash., is chairman of the region, and is directing arrangements for the convention.

LUNAR PERSPECTIVE

Arthur W. Payne, 11223 Balfour Rd., Detroit, Mich., writes concerning the back cover of the full moon in the April issue:

"I have mounted the photograph of the moon under an 8-inch plano-convex lens in a plastic case. When I hang it on the wall it creates an illusion that certainly is realistic."

THIS MONTH'S MEETINGS

Chicago, Ill.: Burnham Astronomical Society members will be guests of the Adler Planetarium at 8 p.m., Tuesday, June 13th, by invitation of Wagner Schlesinger, director of the planetarium.

Columbus, Ohio: The Columbus Astronomical Society will meet on Thursday, June 1st, at 8 p.m. at the Perkins Observatory, Delaware. Dr. J. Allen Hynek will conduct the meeting.

Dallas, Tex.: At the June 26th meeting of the Texas Astronomical Society, Miss Caroline Carlisle will speak on "The Mythology of the Constellations." There will also be a showing of an astronomical film. The meeting is in the Dallas Power and Light Company auditorium, at 8:00 p.m.

Detroit, Mich.: On June 4th, the Detroit Astronomical Society will hold its annual meeting at the Cranbrook Institute of Science, Bloomfield Hills, Mich. As in past years, members will bring their portable instruments for group observations after dark, and probably the institute's 6-inch refractor will also be in operation.

Geneva, Ill.: The annual picnic of the Fox Valley Astronomical Society will be held at Aurora College on Sunday, June 11th. At 5:00 p.m., Wagner Schlesinger, director of the Adler Planetarium, will speak on "Earth's Day Star." At 6:30 a picnic supper will be held on the college campus, followed by observing at 9:00 p.m.

Indianapolis, Ind.: On Sunday, June 4th, at 8:00 p.m., the Indiana Astronomical Society will hold an observation meeting at 2908 N. Meridian St., when Russell Sullivan will speak on "What Telescopes Show." This is the first of a series of summer observation meetings that are open to the public.

Kalamazoo, Mich.: James Sigler will speak on "Ancient Astrology," and Burke Hazelrigg will give "A Biographical Sketch," at the June 17th meeting of the Kalamazoo Amateur Astronomical Association, 8 p.m. at the home of Mr. and Mrs. Sigler, 211 Sydell Ave.

Kansas City, Mo.: Dr. N. Wyman Storer, University of Kansas, will speak on "The Time Table of the Universe," at the banquet of the mid-central states amateur convention, Saturday evening, June 17th. The banquet will take place at the Melrose Methodist Church at 6:00 p.m.

Pittsburgh, Pa.: On Friday, June 9th, at 8:15 p.m., the Amateur Astronomers Association of Pittsburgh will meet at the Buhl Planetarium. An "Astro-Quiz" program will be featured.

San Diego, Calif.: Dr. Edward D. Goldberg, Scripps Institution of Oceanography, will address the San Diego Astronomical Society on Friday, June 2nd, at 7:30 p.m., on the subject, "Chemical Abundance: A Cosmological Research Tool." The meeting is in Room 504 of the Gas and Electric Building. Visitors are welcome.

Washington, D. C.: The National Capital Astronomers, in conjunction with the National Capital Parks Camp Fire Group, will hold an outdoor meeting in the Sylvan Theater on the monument grounds, Saturday, June 3rd, at 8 p.m. Dr. Paul Watson, of the Maryland Academy of Sciences, will speak on "Exploring the Universe." If the weather is bad, the meeting will be held in the Department of Commerce auditorium.

LETTERS

(Continued from page 188)

between the halos, on a level with the sun.

A peculiar ellipse centered on the sun was seen from about 15:00 to 16:00. This was right on the 22-degree halo above and below the sun, but about five degrees outside of it at the same altitude as the sun. The ellipse and the primary halo were about two degrees thick. Featuring the display at this time, however, were four arcs each about 15 degrees long, colored, bright, and crossing both ellipse and halo at points 45 degrees and 135 degrees from the vertical through the sun. Extensions of these arcs would probably have included the sun; they were concave to points above and below the sun where the halo and ellipse joined. Parts of the outer halo appeared about 15:45 as sundogs. Also present during this hour was a horizontal circle or ring entirely around the sky at the same altitude as the sun.

At 20:30, the ellipse reappeared, six degrees from the ring at its extremities. The horizontal circle was very faint. At 21:00 there were sundogs at both circles. At 21:15 the second ring reappeared. At 21:45 a bright broad rainbow color appeared 10 degrees above the western horizon, 12 degrees long and on both sides of the sun. The far part of the horizontal circle was visible, and very bright colors were seen on the outer halo toward the zenith. The inner halo was also colored, although it was rather bright as a whole.

At 22:15 the bottom of the inner ring was at the horizon, and only portions of other features of the halo complex remained visible. The sunlight was faint, but I could not look directly at the sun. The circumzenithal arc appeared at the top of the outer halo, which looked like a faint rainbow. At 23:40 the sky was clearing, with sundogs on both sides of the sun, the north one bright, the other faint. At 23:50 the display was just about all gone.

E. H. PILSWORTH
P. O. Box 964
Battle Creek, Mich.

Ed. Note: Deduct five hours from Mr. Pilsworth's times to get his local standard time; about 5¾ hours for his local civil time.

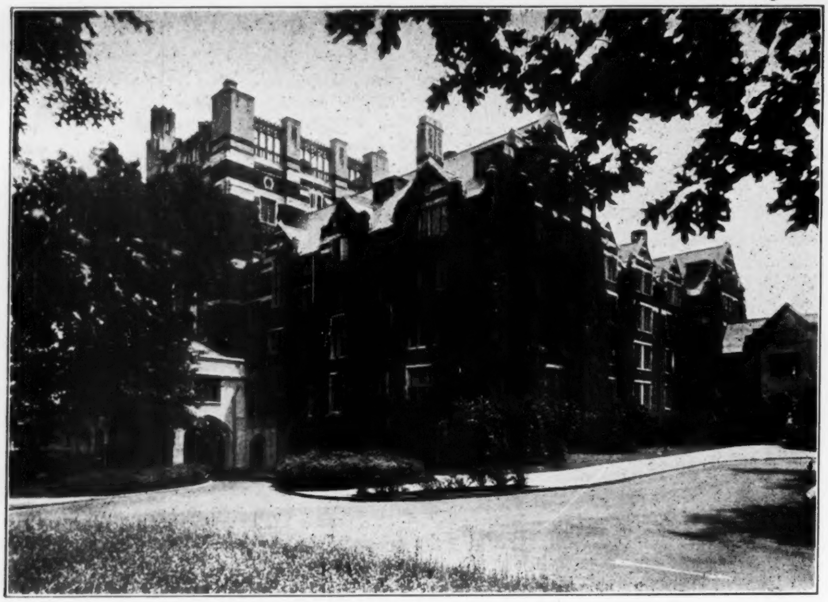
Sir:

On Tuesday, April 11th, at 9:00 a.m. PST, several of us here on the Washington State College campus observed a striking halo that in many ways departed from the "normal" appearance of the phenomenon as given in "Stamford Halo Complex," **Sky and Telescope**, May, 1948.

The horizontal circle was outstanding over the entire 360 degrees of the sky, resembling a sky-writing job. The sundogs were **not** on the 22-degree halo, but some distance to each side, on a sort of egg-shaped halo. One 120-degree countersun was very brilliant. Above and below the sun next to the 22-degree halo were colored arcs and there were two additional arcs at the sun's level far to each side beyond the limits of the larger halo.

Why is this so different from the description given in the article quoted above? Every feature mentioned above was plainly visible.

PERRY B. WILSON
Waller Hall, Pullman, Wash.



Tower Court, on the Wellesley College campus, where the Astronomical League convention will be housed, July 1-4, 1950.

Final Notes on the Wellesley Convention

PROGRAM DETAILS, exhibit plans, and other arrangements are virtually completed for the Astronomical League convention to be held at Wellesley College, Wellesley, Mass., July 1st to 4th. Present registration is about 150 persons, but the Wellesley accommodations are by no means filled. The convention is open to everyone, and further reservations may be made by sending a deposit of $5.00 (per person) to the undersigned. See the March issue of **Sky and Telescope** for details of registration and the general program of the convention. If you do not have that issue, send a stamped self-addressed envelope to the undersigned for a reprint.

Exhibit. Under the chairmanship of Winfred A. Shattuck, the exhibit committee has prepared a set of rules, separating exhibits into the following categories:

1. Amateur-made telescopes.
2. Photographs of amateur-made telescopes and observatories.
3. Models of instruments; teaching aids.
4. Parts and accessories, amateur made, such as eyepieces, mirrors, diagonals, finder scopes, spectroscopes, focusing devices, tripods, mountings, and slow-motion drives.
5. Astronomical photographs taken with amateur telescopes; paintings or drawings of astronomical subjects; charts and maps.

A competent committee of judges will award prizes on the basis of best construction, arrangement, finish, machine work, and completeness; best optical performance in night tests on stars; best advanced instrument; best instrument constructed by a junior, 18 years or younger; best display other than instruments, or most unique.

Rules regarding categories 1, 3, and 4: All instruments, devices, and accessories must be brought to the convention, not shipped, and space will be provided to set these up. Unassembled parts must have each individual piece tagged with the name and address of the owner.

Rules regarding categories 2 and 5: Paintings, drawings, charts, maps, and photographs must be without frames or glass, not less than postcard size, must have name and address of the exhibitor on the back, and an additional sheet of the same size giving information of interest. These items may be sent in advance, postpaid, to the undersigned.

All exhibits must be removed from the exhibit hall at Wellesley by 11 a.m., Tuesday, July 4th. All entries are at the owner's risk, but every effort will be made to protect exhibits from loss or damage. The value of each exhibit must be stated. Exhibits will be accepted until noon on Sunday, July 2nd, provided the exhibitor signifies to the undersigned by June 20th what he intends to exhibit and when he will ship or bring it.

Program notes. The morning session from 11:00 a.m. to 12:30 p.m., Sunday, July 2nd, is "Observing for Amateurs," under the chairmanship of Mrs. Grace C. Rademacher, New Haven Amateur Astronomical Society. Dr. Harlow Shapley, director of Harvard Observatory and chairman of the technical advisory council of the league, will present a 20-minute report. Other reports will be made by the activities committee, Rolland R. LaPelle, chairman, and the junior activities committee, Grace C. Scholz, chairman. There will be brief reports of society observing programs, and of work by juniors.

Mrs. Margaret W. Mayall, recorder of the American Association of Variable Star Observers, will be chairman of the first session Sunday afternoon, 2:00 to 3:30 p.m. Among the speakers will be Leon Campbell, honorary AAVSO recorder; Dr. Dorrit Hoffleit, Harvard College Observatory; Ralph N. Buckstaff, chairman of the North Central region; and R. Newton Mayall, co-author with Mrs. Mayall of the book, **Skyshooting**. Jeremy Knowles, of Marblehead, Mass., will describe the novae as "Stellar Glamour Boys."

There will follow papers on solar, aurora, occultation, and meteor observing, under the chairmanship of Harry B. Chase, AAVSO solar division member. Participants will include Paul W. Stevens, Rochester Academy of Science, and three members of the New Haven society, Vincent Anyzeski, Donald S. Kimball, and J. J. Neale. This session was originally scheduled for Monday; both its day and time have been changed.

With Stanley Brower, Northeast representative on the league council, in the chair, the instruments section will take place Monday morning at 10:15. In addition to papers on various aspects of instrument making, there will be a demonstration of a photoelectric photometer by Mr. Brower, and Carl F. Alsing will show a motion picture of the grinding and testing of the Springfield STARS Club 20-inch mirror.

The change in program places the lunar and planetary section meeting at 1:30 Monday afternoon, and John W. Streeter, Vassar College Observatory, will preside. Reports from section recorders of the Association of Lunar and Planetary Observers will be presented by amateurs familiar with these fields. Dr. Joseph Ashbrook, of Yale University Observatory, will speak on "A New Aspect of Planetary Observing," and Raymond Missert, of Buffalo, N. Y., will discuss variations in the brightnesses of Saturn's satellites.

Added to the schedule on Sunday evening following the panel of experts is a talk by David A. Batchelor, of the Amateur Astronomers Association of Pittsburgh. His "Trip Through the Solar System by Rocket" will be illustrated by pictures of his own making. If observing conditions are very favorable on Sunday, this talk may be held over to Monday evening.

A tea and social hour has been arranged for Tower Court at 4:00 in the afternoon on Monday, July 3rd, to be followed by a period for recreation, solar observing, and swimming.

Leon A. Burke, Jr., of Lexington, Mass., has offered his services without charge as a guide to points of historical interest in Lexington and Concord on July 4th after the return from the field trip to Harvard's Oak Ridge station. For those who register for this event at the convention, luncheon will be arranged at the Colonial Inn in Concord, and then the tour will start "by the rude bridge that arched the flood." Among other places, Mr. Burke will include Sleepy Hollow cemetery, homes of famous writers, the Lexington battle green, Buckman Tavern, and the Old Belfry that rang out the alarm on April 19, 1775.

CHARLES A. FEDERER, JR.
Chairman, Wellesley Convention
Harvard College Observatory
Cambridge 38, Mass.

TERMINOLOGY TALKS

J. Hugh Pruett

Absolute Magnitude

So far we have discussed only the apparent magnitudes of the heavenly bodies, usually indicated by the letter m. Such magnitudes tell only how luminous these objects seem to us, but nothing about their actual intrinsic brightnesses. In order to calculate this latter characteristic directly, we must know in addition the distance of each light-giving source. For instance, in the case of a faint star, the apparent magnitude does not indicate whether the star is faint because it is exceedingly distant or because it is really lacking in luminosity. Obscuring matter in the space through which the light travels sometimes has to be taken into consideration also.

If we could line up all the myriads of stars, including our own sun, at the same distance from us — not too far away as celestial spaces are concerned — and inspect them at that convenient location, we should be able to obtain real information concerning their relative luminosities. In imagination, astronomers do this very thing, and use the term *absolute magnitude* to indicate the apparent magnitude which a star would have at this ideal distance.

Before we discuss this more fully, perhaps we should review briefly a few terms explained in this column over two years ago. We found that a *light-year,* a measure of space and not of time, is the distance light travels in one year, approximately 5,880,000,000,000 miles. More simply stated, it is six million million miles.

The *parallax* of a star is one half the maximum difference in direction the star appears from us when our earth is first at one part of its orbit, then at an opposite part six months later. Or it may be more conveniently stated as the maximum angle at the star subtended by half the diameter of the earth's orbit. The stars are so extremely distant that if we were at the nearest star known, Alpha Centauri, the radius of the earth's orbit would appear only 0.76 second of arc wide.

A *parsec* is the distance to a star that has a parallax of one second of arc. This is equal to 3.26 light-years, nearer than any known star excepting the sun. Barnard's star, discussed on page 183 of this issue, is nearly two parsecs distant.

Now we are ready to define absolute magnitude, usually denoted by M. It would be the apparent magnitude of a star if it were placed at a distance of 10 parsecs, or 32.6 light-years. The parallax p and the apparent magnitude m are related to M by the formula:

$$M = m + 5 + 5 \log p.$$

The parallax is always the decimal part of a second of arc. The logarithm of this decimal is always negative, but if it is expressed in such a form as 9.1367 − 10 (the logarithm of 0.137), for example, there should be no trouble in handling it.

Typical values of these three quantities for some stars are:

Star	M	m	$p,''$
Sun	+4.9	−26.7	—
Sirius	+1.3	−1.58	0.381
Vega	+0.5	+0.14	0.123
Rigel	−5.8	+0.34	0.006
Antares	−3.2	+1.22	0.013
Proxima Centauri	+15.4	+11.0	0.761

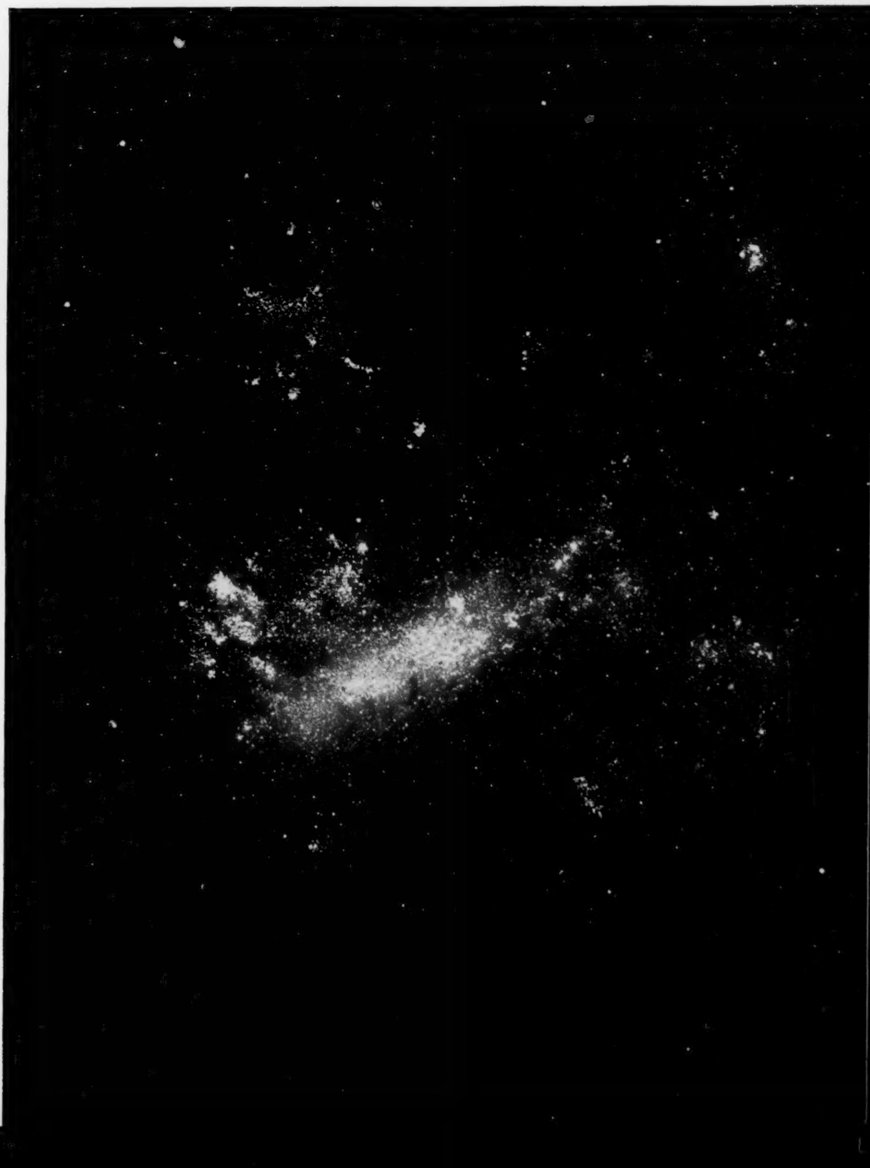
The star of faintest intrinsic luminosity known is the red one in Aquila discovered by Van Biesbroeck in 1943. Its absolute magnitude is +19.2. It is only 19 light-years distant. The star of greatest known intrinsic brightness is S Doradus in the Large Magellanic Cloud, with an absolute magnitude of about −9. Its apparent magnitude is +9, a decidedly telescopic object. Our modest Old Sol comes about midway between these extremes of luminosity. S Doradus is roughly 400,000 times as bright as the sun, and the sun is about 400,000 times as bright as Van Biesbroeck's star.

Distance Modulus

A general idea of the relative distance of an object may be obtained from a quantity known as the *distance modulus.* The expression for this is $m - M$. If this is zero, the distance is 10 parsecs, the standard for absolute magnitude. If the distance modulus is negative, the star is nearer than 10 parsecs, but the term is very rarely used in such a case.

Distance modulus is mostly used for remote clusters and galaxies, where the difference between the apparent and absolute magnitudes is so great that the distance modulus may be a large number. For instance, the distance modulus of NGC 2419, pictured on last month's back cover, is about 19 magnitudes, corresponding to a distance of 185,000 light-years.

The Large Magellanic Cloud, 75,000 light-years distant, contains S Doradus. This star is located in the bright region known as NGC 1910, which is 3½ inches from the top and 2¾ inches from the left side of the picture. Harvard Observatory photograph.



BOOKS AND THE SKY

THE HISTORY OF NATURE

C. F. von Weizsaecker. University of Chicago Press, Chicago, 1949. 191 pages. $3.00.

DR. VON WEIZSAECKER is a leading European physicist, and one of the most original thinkers in modern cosmogony. He is known to astronomers for his theory of the origin of the solar system, and for his still more far-reaching speculations on the genesis and development of stellar systems and of stars. All who are interested in astronomy will find his popular account of these tremendous cosmogonical speculations an absorbing piece of reading, couched in graphic, lucid language.

The account of planetary and stellar evolution comprises only one of the 12 chapters of **The History of Nature.** The author grapples with a wider question: "What is the meaning of my inquiry for the lives of my fellows?" And in a small volume he has produced a profound and mature work, a book that will repay serious and careful reading, and that cannot fail to broaden the outlook and to stimulate the thinking of the reader.

The first chapters define the limits of our knowledge, and the author's preoccupation with the historical nature of our picture of the world explains the book's title. Deeply versed in philosophy, he approaches the physical aspects of the universe with illuminating discussions of space, time, and infinity. The reader is led through these difficult metaphysical concepts, yet has the sense of never losing touch with reality.

The five chapters that follow cover the amazing range from the genesis of atoms to the nature and problems of living matter. Dr. von Weizsaecker performs an astonishing feat of exposition in giving a coherent picture of the whole gamut of the observed universe, although detailed presentation of facts is obviously impossible.

The three closing chapters, which discuss the soul, the "outer and inner history" of man, and the role of religion, are perhaps the most interesting in the book. They radiate, with evident sincerity, the attitude of a thinking scientist toward the world of history and to his fellow creatures. There may be some readers who have followed the author through the earlier chapters who will part company from him here. The argument has passed out of the strictly scientific sphere. But the line of demarcation is hard to draw, for the whole book is suffused with a light that seems touched with inspiration.

Yet the light is a somber one. The world picture of von Weizsaecker seems to lack something. Suffering and duty play a large role, but we look in vain for the beauty and the joy that some of us draw from a contemplation of the universe. Just for these reasons, perhaps, the serious reader will find the book most rewarding.

The History of Nature has been translated from the original German text. That the wording is sometimes obscure is probably no fault of the translator. The subtleties of the author's thoughts are difficult to translate, even in the domain of astronomy.

CECILIA PAYNE-GAPOSCHKIN
Harvard College Observatory

ATOMS IN ACTION

George Russell Harrison. William Morrow and Co., New York, 1949. 406 pages. $5.00.

SCIENTIFIC ADVANCES are no longer solely the concern of erudite gentlemen who ponder the structure and workings of the universe. During the past decades the immediate exploitation of such advances through technological development and distribution of new or

better products has brought science to the attention of everyone. But frequently the means by which the original investigations were fitted together to permit some major development are so glossed over that the scientific enterprise takes on an aura of magic. A highly readable account of how modern science actually progresses is given in **Atoms in Action,** by the dean of science at Massachusetts Institute of Technology.

This popular book, now revised to include the major progress achieved during the past war, presents the reader with a non-technical description of many scientific devices and theories which have important relations to industrial, political, and international problems.

Although astronomy as such is not discussed, and we would not expect it to be among the major topics in this volume, interested amateurs will find that the book adds to their understanding of recent astronomical developments. For the rapid technological exploitation of scientific advances provides not only new materials for commerce, but new tools for other sciences. Developments in short-wave radio and radar have opened new fields of astronomical investigation. New types of photosensitive cells permit rapid comparisons of stellar brightnesses accurate to a thousandth of a magnitude. New types of glass and of structural steel permit new or better instruments. Each of these in turn, through expansion of theories of atomic behavior under extreme conditions, feeds back into the general stream of scientific activity. Throughout a book such as this we can find in numerous instances where astronomical work has been exceedingly important in adjacent areas of study. Dean Harrison's excellent book emphasizes the continual interplay among the various sciences.

FLETCHER G. WATSON
Harvard University

SOME RECENT RESEARCHES IN SOLAR PHYSICS

F. Hoyle. Cambridge University Press, New York, 1949. 134 pages. $3.00.

THIS BOOK, written by one of Britain's leading astrophysicists, is a Cambridge monograph on physics and is primarily for the expert. To make headway with the text, one must have a good background in vector analysis and differential equations, as well as in a number of branches of physics.

For the serious student of astronomy, however, the book is a must. It is very clearly written. In the 131 pages of text, Dr. Hoyle covers a wide variety of subjects. He starts out with discussion of sunspots in a solar cycle, and his treatment of magnetic fields in moving material is basic. One of the points that he emphasizes especially is that the magnetic fields of spots are not produced **in situ.** In other words, he believes that the magnetic fields exist apart from the birth and decay of spots. And the magnetic fields result from the concentration of magnetic lines of force in certain areas, through the moving gases.

He discusses the equilibrium of the chromosphere and corona among his more interesting conclusions, and one with which I heartily agree is that "prominences must be regions of local cooling in the corona." However, I am unable to agree that the evidence for the presence of moving absorbing clouds of gas between the earth and the sun is particularly striking.

He concludes the book with a discussion of electromagnetic phenomena, including the emission of radio waves from the sun.

Some of the subjects discussed are, admittedly, of a highly controversial nature. I am sure that the author does not expect 100 per cent agreement with his conclusions. All astronomers must agree, however, that Hoyle has contributed a great deal to the advance of solar astrophysics by the publication of this book.

DONALD H. MENZEL
Harvard College Observatory

NEW BOOKS RECEIVED

ASTRONOMY, *Robert H. Baker,* 1950, *Van Nostrand.* 526 pages.

The fifth edition of a standard text for university and college students, considerably rewritten to include developments in the science since publication of the fourth edition in April, 1946.

THE FOUNDATIONS OF ARITHMETIC, *G. Frege,* translated to English by J. L. Austin, 1950, *Philosophical Library.* 119 pages.

The original of this work, published in Breslau in 1884, is reprinted here on left-hand pages, with Mr. Austin's English translation facing on the right-hand pages. The book is subtitled, "A logico-mathematical enquiry into the concept of number," and was written by an obscure German professor at the University of Jena.

GLEANINGS FOR ATM's

EDITED BY EARLE B. BROWN

NOTES ON THE SECONDARY REFLECTION — I

BY ALLYN J. THOMPSON

WHEREVER telescope optics are discussed among amateur telescope makers, the conversation dwells largely on the primary mirror. The little secondary is generally neglected; it tags along forlornly like a puppy on a leash. Many amateurs manage to put telescopes together without knowing anything at all of the manner in which the secondary reflection functions. Perhaps this is because the secondary mirror has none of the imagination appeal that surrounds the primary — yet it has the same kind of influence on the image that any change in the size, shape, figure, or position of the primary mirror would have.

Questions concerning such matters as relative merits of prism and diagonal, best size, shape, flatness, positioning and alignment, ought to be given careful consideration if the amateur hopes to get the most out of his telescope. With the assistance of computations made for two popular sizes of telescope, a 6-inch f/4.4 and a 6-inch f/8, we shall try to furnish answers to these questions. The focal ratio f/4.4 is adopted here because it may be used with a readily obtainable eyepiece of $1\frac{1}{4}''$ focal length to combine the advantages of large field and exit pupil. Thus it more practically represents the rich-field type of telescope than does f/4, for which the eyepiece focal length ought to be about $1\frac{1}{8}''$; this is not so easily procurable.

Dimensions. In the absence of a secondary reflection, the primary mirror will image an axial star at **f** in Fig. 1, where visually it is out of reach. If a plane reflecting surface is placed in the plane **bb'**, perpendicular to the axis of the mirror, the star will be imaged at **f'**. The section of the cone thus intercepted is circular in outline; the diameters **a'a"** and **bb'** are therefore equal and are equal linearly to **Ap/F**, where **A** and **F** are, respectively, the aperture and focal length of the primary mirror, and **p** is the distance **af**. The image **f'** is, of course, as inaccessible as before, but by tilting the plane reflecting surface about axis **a'a"** until its inclination to the mirror axis **sf** is 45°, the extension of the mirror's axis **af** will be deflected 90°. The star will now be imaged at **f"**, where with the aid of an eyepiece it can be examined by the eye.

The shape of the conic section in the 45° plane of interception is that of an ellipse. The axis **a'a"** about which the plane mirror was rotated in effecting the 45° inclination is not, however, the minor axis of the ellipse. The minor axis lies a short distance toward the mirror, and is shown by the broken line through **x** in Fig. 1. The point **x** is therefore the geometric center of the ellipse, while the point **a** may be called the optical center. The dimensions of this ellipse depend on the angular aperture **w** of the primary mirror and on the distance **af** or **p**. Although here we have cut a cone, the ratio of the ellipse's major axis to its minor axis is nearly the same as if we had cut a cylinder, in which case the ratio would be 1.414, the square root of 2.

It is evident also that the actual minor axis of the ellipse is slightly larger than **a'a"**, but the difference is small and the expression **Ap/F** can be used without serious error. At f/4.4, for example, the exact length of the minor axis is only 1.3 per cent more than would be thus computed; at f/8 it is about one half per cent greater.

In practical telescope making, however, an extended focal plane **v** is considered instead of a single point **f**, as is shown in the plan of the optical system of Fig. 2. The diameter assigned to the field of view **v** is purely optional, and is for the most part arbitrarily selected, as we shall see below. The values for diagonal sizes and other incidental dimensions are given in the table that accompanies Fig. 2. In telescopes of similar focal ratio, where the value of **v** is different from the one given here, a close approximation to true figures can be arrived at by applying the ratios **d'a/da**, and **d'm/dn** from the table. Variations in **v** not exceeding $\frac{3}{8}''$ will introduce only trifling error. (See size of the field discussion below.)

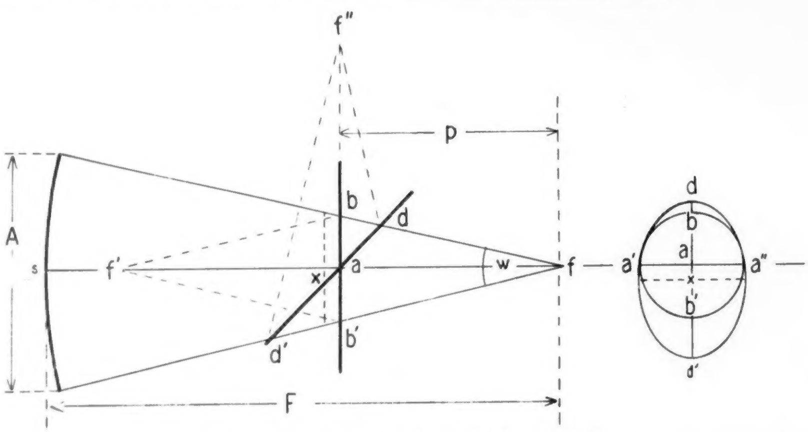


Fig. 1. The effect of the secondary reflection.

It is customary next to indicate at an optimum distance **p** inside of focus the minor axis dimension of the elliptical surface by drawing **bb'** through **a.** The major axis is then indicated by drawing **dd'.** Letting **bb'** equal **y,** we can derive the following formula for the length of the minor axis:

$$\mathbf{yF} = \mathbf{p}(\mathbf{A}-\mathbf{v}) + \mathbf{vF},$$

where **p, A,** and **F** have the meanings previously assigned. To get the major axis length approximately, **y** is multiplied by 1.414, which is the ratio we would have were we cutting a cylinder instead of a cone. The actual ratio is a somewhat complex function of the focal ratio, which is nearly 1.414 for all practical cases. The discrepancy is significant only for very short focal ratios.

Again we encounter the fact that **x** and not **a** is the geometric center of the secondary ellipse; the true minor axis location is shown by the dotted line through **x,** the midpoint between **d** and **d'.** A diagonal that is manufactured to the specifications derived from the above formula will obviously be slightly smaller than what is actually needed for an evenly illuminated field of diameter **v.** As in the previous fundamental case, however, the difference is inconsequential. If **v** equals 5/8", the ellipse computed from the formula is, for a 6-inch f/4.4 mirror, only 2.1 per cent less in area; and for a 6-inch f/8 the difference is barely more than one half per cent. For practical purposes, therefore, the formula is entirely valid, as these percentage differences will vary hardly at all for any telescope of ratio f/4.4 or f/8.

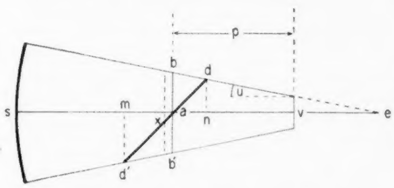


Fig. 2. A field of view is added to secondary reflection considerations.

Table of Dimensions

	6" f/4.4	6" f/8
v	0.625	0.625
u	5° 48'.75	3° 12'.27
p	4	6.5
bb'	1.439	1.352
da	0.923	0.905
d'a	1.133	1.013
major axis	2.056	1.918
dn	0.653	0.641
d'm	0.801	0.716
minor axis	1.454	1.357
ax	0.104	0.053
offset (**xv − av**)	0.074	0.037

(All dimensions are given in inches.)

Prism or flat? Either a totally reflecting right-angle prism having square faces, or an aluminized plane mirror (diagonal or flat) may be used to give the secondary reflection. But a prism whose hypotenuse surface is of the same size as that of the diagonal will not accommodate the same size of field. This is made apparent in Fig. 3, where both prism and diagonal mutually share the same plane of reflection. In order that the prism's entrance face may have sufficient breadth to include all of the rays making up the indicated field, prism **d'ed** would have to be increased in size to **d'gf.** No simple formula can be written to give precisely the required size of **d'g,** but a very close approximation is had by adding, at f/4.4, 11.3 per cent to the value of **y** derived from the formula given above. At f/8, 5.8 per cent should be added.

A diagonal may be cut and edged to the rectangular shape shown in Fig. 4, or it may be made elliptical in outline. In the telescope the elliptical diagonal presents a nearly circular obstruction to the incoming light, while the rectangular diagonal and the prism present the outline of a square. Either of these, of course, obstructs more light than the conforming elliptical diagonal, with the prism obstructing the most because its dimensions must be greatest, as we have seen.

In the matter of light reflection and transmission efficiency, prism and diagonal are about equal, although if the entrance and exit faces of the prism are

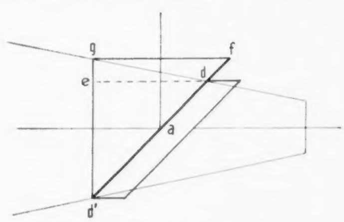


Fig. 3. To intercept the same cone of light, a prism must have greater dimensions than the corresponding flat mirror.

fluoride coated, it will transmit nearly 10 per cent more light than the diagonal reflects. Furthermore, in actual practice the diagonal's efficiency may frequently drop to as much as 50 per cent below that of the prism, because the telescope owner hesitates to clean its surface until there is quite an accumulation of dirt and film. And with each cleaning some of the reflective film is removed. The prism surfaces, on the other hand, can be cleaned as frequently as needed without inflicting damage.

If the prism size is kept within recommended limits, its diffraction effects will be negligible. Since with the passage of time it will excel the diagonal in reflectivity, and it perhaps more readily lends itself to perfection of alignment (to be discussed next month), in this writer's opinion it must be awarded preference over the diagonal flat.

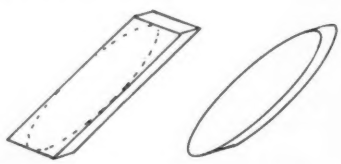


Fig. 4. A rectangular diagonal may be "rounded off" to obstruct less light in the elliptical form.

Size of secondary. The presence of a central obstruction in front of the mirror has an injurious effect on the image. This is an important consideration because the occasioned diffraction accounts in the main for the inferiority of the reflector when it is compared with a refractor. It is found that the diffraction ring brightness is increased, and light that is diffracted by the margins of the secondary is scattered throughout the diffraction pattern, so that a star image is seen as though set in a faintly luminous aura, instead of against a jet black background. In the case of an extended object such as the moon or a planet, contrasts become impaired and definition suffers. The scattered light is most evenly distributed when the obstruction is circular in outline; a somewhat less orderly effect occurs from the square outline of a prism or a rectangular diagonal.

Both theory and experiment agree fairly well that the detrimental effect becomes rather conspicuous when the diameter of the obstruction is more than about one fourth that of the mirror. For best optical performance, therefore, the width of the prism or diagonal should be kept well under that figure.

Another important and little considered reason for keeping the secondary mirror diameter small, in the case of short-focus telescopes, is the size of its projected silhouette. This image of the secondary's reflection in the primary mirror falls just inside the plane of the exit pupil. Many amateurs possessing rich-field reflectors are favorably situated where horizons are unobstructed and panoramic scanning of distant shoreline or hillside may be enjoyed by day. But if the shadow of the secondary is so large as to block the pupil of the eye from direct seeing, then daytime use of the telescope will be anything but a pleasure.

The secondary mirror shadow becomes annoying, in bright daylight, when its image diameter goes over about 1.7 millimeters; at two millimeters it is decidedly disagreeable; and over this the condition may be such that for daylight observing the wide-field low-power eyepiece will be rendered useless. In our f/4.4, the image of the secondary at the exit pupil of a 1¼" eyepiece is about 1.75 millimeters in diameter.

Size of the field. Finding a logical reason for the dimension that is prescribed

for **v**, from which is established the size of the secondary mirror, is a matter that is usually avoided by most amateurs. Fitting **v** to the field of a low-power eyepiece does not work out so well, as we shall see. Fitting it to an eyepiece of any power has questionable merit, unless only that one eyepiece is to be used in the telescope. An argument might be found, however, in favor of the eyepiece that theoretically just reveals the diffraction pattern, that is, which gives a magnification of about 13 per inch of aperture. In a 6-inch f/8 telescope, this would be an eyepiece of about 5/8" focal length; if its apparent field were 40° it would embrace a linear field a little more than 2/5" in diameter. By coincidence this is just about the size of the moon's image, and so might well be taken as the minimum size for **v** in that telescope.

The usual practice of fixing a width for **v** first and from that working toward a size for the secondary may not always be the most convenient method. We could instead choose from manufacturer's stock sizes a diagonal having a breadth **x** that is less than 25 per cent of the mirror's diameter, and then determine from the following formula the size of the field obtained:

$$vd = xF - Ap.$$

The meanings of **A**, **p**, and **F** have been previously explained; **d** is the distance from the mirror to the diagonal and should be as great as it can conveniently be made.

If a prism is going to be used, then in the application of the above formula **p** must first be increased and **d** decreased by one half the prism's square face dimension. This formula might prove useful for rich-field telescopes, since the low magnification used does not require the best in imagery; thus it may be wisest to choose a diagonal or prism that is larger than the recommended size, unless terrestrial observing is to be considered.

Surface tolerance. The question of flatness remains to be considered. The dimensions of the ellipse involved in point image formation are derived in the manner described for the fundamental Fig. 1. The major axis of that ellipse is the basic dimension to which surface tolerance is referred. For example, if we have a perfect mirror, but will be content with a half-wave path difference in the image, then along **dd'** the surface must depart from flatness by no more than a quarter wave length. Of course, to take in a field of finite size, the surface of the diagonal or prism must be larger than that of Fig. 1, as we have seen. The deviation varies as the square of the diameter, and the required tolerance for the whole surface is equal to b^2t/k^2; where **k** is the minor axis width as illustrated in Fig. 1, **b** is the minor axis width indicated in Fig. 2, and **t** is the desired tolerance for the surface used in point image formation. From this formula it is found that the diagonal for our 6-inch f/8 telescope may depart from flatness (along its major axis) by no more than about 7/10 of a wave.

It is seldom, however, that we find a perfect mirror. Where more than one reflection is used in arriving at the image, the tolerance **t** becomes more severe. For a half-wave path difference in the image, in the case of two reflections, it is 1/5.6 of a wave length.

(To be concluded)

GLEANINGS is always ready to receive reports and pictures of amateur instruments and devices, and is open for comment, contributions, and questions from its readers.

OBSERVER'S PAGE

Universal time is used unless otherwise noted.

VISUAL OBSERVING PROGRAMS FOR AMATEURS — III

Instruments — (Continued)

BINOCULARS. Suppose that we have a small finder telescope of 6 power with an objective 30 millimeters in diameter and a field of view of 7½ degrees. If we insert suitable erecting prisms in the optical train it will become a monocular. It will be shorter than before and will give an erect image. The power, aperture, and field will remain unchanged at 6x, 30 mm., and 7½°, respectively. Two monoculars form a binocular, and this size is called 6 x 30. The field of view is usually not specified, but it may be referred to in the maker's catalogue as "130 yards at 1,000 yards" (7½ degrees).

Prismatic binoculars have wider fields of view than Galilean field glasses. For astronomical work they are well worth the extra cost. The principal value of binoculars is in sweeping the sky. Because they are held by hand they are more convenient for this purpose than is a finder fastened to a telescope. Their erect field is also a definite convenience. A monocular is nearly as good, but is a little harder to point.

For most astronomical purposes small binoculars are best. The writer has 7 x 32 and 15 x 60 binoculars, and other observers have used 24 x 54 binoculars successfully. These latter must be mounted on a stand. The writer's present opinion is that above 6 or 8 power it is better to use a powerful finder, such as 12x with 1½ to 2 inches of aperture, and above that to go to a 3-inch refractor with a 25x wide-angle eyepiece.

Small binoculars serve a distinct function in visual observing. They show stars to about the 8th magnitude, thus carrying down from about 4th or 5th magnitude (all most city dwellers can see) to the limits of such star atlases as the Skalnate Pleso.

Suppose that one wishes to look for Luyten's flare star. The AAVSO charts show that it is just south of Tau Ceti. One may be uncertain where Tau is, either from lack of familiarity with Cetus, or because moonlight obscures the fainter stars. A finder will show where Tau is, but a hand-held 6x binocular will tell us faster, as it will be of lower power and wider field. It will also be more mobile than a 12x or 15x finder mounted on the relatively larger telescope needed to see Luyten's flare star at its minimum of 12.2 magnitude.

When hunting for Mercury in the twilight, for a comet whose location is somewhat uncertain, for diffuse nebulae, or for star clusters, binoculars are the most convenient instruments because one can sweep large areas of the sky with them.

Also, the fact that binoculars can be swung rapidly back and forth from a comet or variable star to the comparison stars makes them decidedly superior to finders for these purposes. The wide field and low power of binoculars is of value when estimating the brightnesses of such variable stars as R Scuti, R Coronae Borealis, Omicron Ceti, R Leonis, T Cephei, Chi Cygni, and novae, when between 5th and 7th magnitudes. For the comparison stars may be, perforce, widely separated from the variable star.

If one wishes to time a minimum of Algol, the best procedure is to use binoculars and throw the image of Algol out of focus. This expanded circle of light can then be compared with the out-of-focus images of the comparison stars used, and the results are more accurate than obtainable by naked-eye comparisons. The same is true of estimates of the brightness of a comet.

Rich-field Telescope (RFT). On page 16 of the November, 1949, issue of **Sky and Telescope** will be found the picture of a 4¼-inch RFT of 15½ inches focal length, on a tripod mounting with a 6x finder. This reflector was designed by its maker, Roy A. Seely, former president of the AAVSO, to give views of maximum richness in the Milky Way. For that purpose it was excellent.

I used this instrument for a number of years for variable star work. With a 14x eyepiece it was very convenient for variables down to about the 10th magnitude. With a 40x eyepiece of 0.4-inch focal length, one could glimpse SS Cygni at minimum of 11.8, but the image was unpleasantly fuzzy with this power. This telescope was of no use on the moon or planets, as 14x was about the limit of power for good definition. In an attempt to adapt it for solar use the aluminum coatings were removed from the mirror and diagonal, and the mirror was moved up in the tube to make it possible to introduce a third reflection off unsilvered glass. But here again 14x was about the limit of power, and this is not enough for solar work. RFT's are specialized telescopes, and should be used only for looking at the Milky Way, and possibly for variable star work in the 7th- to 10th-magnitude range.

DAVID W. ROSEBRUGH
79 Waterville St.
Waterbury 10, Conn.

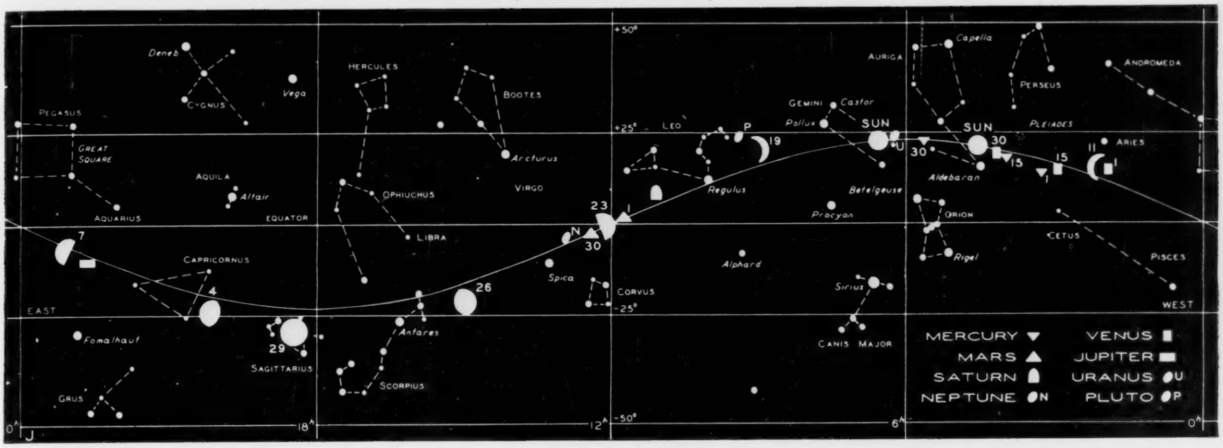
UNIVERSAL TIME (UT)

TIMES used on the Observer's Page are Greenwich civil or Universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the UT before subtracting, and the result is your standard time on the day preceding the Greenwich date shown. Add one hour for daylight time.

TELESCOPIC METEORS

Robert M. Adams, 324 South Valley, Neosho, Mo., has reported to the American Association of Variable Star Observers as follows:

"While awaiting darkness to approach before starting my evening of variable star work, April 19-20, I had my 3¼-inch refractor trained on the thin crescent moon. To my surprise I saw a bright flash that started and finished entirely within the boundaries of the moon's disk. I am not going to offer an explanation. The trail



THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month and for other dates shown.

started as a narrow path — widened when brightest — then narrowed and faded. The time was 7:45 p.m. CST, and I observed with 80 power and a ½-inch eyepiece. The trail was about 10 minutes of arc long."

Reginald V. Tims, 50 Mortimer Rd., Hackney, London N.1, England, wrote on April 11th:

"A few nights ago, whilst observing Saturn telescopically, and using a magnifying power of 100x, I was fortunate enough to observe a high-altitude meteor which crossed the field of view a little below the planet. Its duration was about one second of time, and its apparent magnitude about 8. It extended somewhat less than half the field of view, which was about one third of a degree."

MINIMA OF ALGOL

June 2, 19:25; 5, 16:14; 8, 13:03; 11, 9:51; 14, 6:40; 17, 3:29; 20, 0:18; 22, 21:06; 25, 17:55; 28, 14:44. July 1, 11:33; 4, 8:21; 7, 5:10.

These predictions are geocentric (corrected for the equation of light), based on observations made in 1947. See **Sky and Telescope**, Vol. VII, page 260, August, 1948, for further explanation.

VARIABLE STAR MAXIMA

June 1, U Ceti, 7.5, 0228**13**; 1, Z Puppis, 7.9, 0728**20**b; 8, T Cephei, 5.8, 210868; 12, S Carinae, 5.7, 1006**61**; 12, R Virginis, 6.9, 123307; 12, R Hydrae, 4.6, 1324**22**; 23, R Serpentis, 6.8, 154615; 27, R Octantis, 7.9, 0556**86**; 30, T Aquarii, 7.9, 2044**05**. July 1, RV Sagittarii, 7.8, 1821**33**.

These predictions of variable star maxima are by Leon Campbell, honorary recorder of the AAVSO. Only stars are included whose mean maximum magnitudes, as recently deduced from a discussion of nearly 400 long-period variables, are brighter than magnitude 8.0. Some of these stars, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the predicted magnitude, and the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern).

Mercury, in the morning sky all month, reaches greatest elongation on June 10th, 23° 45′ west of the sun. This is not a favorable elongation for observers in northern latitudes, because Mercury is south of the sun. At elongation, the planet rises one hour before the sun and is of magnitude +0.7.

Venus may be seen rising as dawn commences, two hours before sunrise. Its magnitude is −3.5, and the disk is now 76 per cent illuminated. At the end of June, Venus will be located between the Hyades and Pleiades in Taurus.

Earth will attain heliocentric longitude 270° on June 21st, at 23:37 UT. Summer commences in the Northern Hemisphere and winter in southern latitudes.

Mars continues to fade in brightness as it comes to eastern quadrature with the sun on June 30th. The ruddy planet is moving eastward between Beta and Gamma Virginis. On the 15th the disk of Mars is 8″.8 in diameter.

Jupiter rises about midnight, located in Aquarius and almost stationary among the stars. The planet cannot be mistaken, for its stellar magnitude is −2.1, and it far outshines all other objects unless Venus or the moon is visible. The Jovian disk is 42″ in diameter at the equator; the polar diameter is 3″ less.

Saturn remains in Leo, moving slowly in direct motion 15° east of Regulus. Eastern quadrature occurs on June 4th, hence Saturn sets about midnight. This month the inclination of the rings will decrease from 4°.6 to 3°.9.

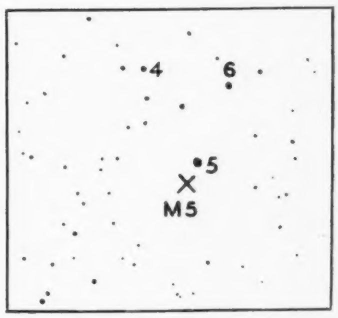
Uranus enters the morning sky on June 27th, and is therefore unobservable.

Neptune may be located with optical aid during the evening hours in June, about 3° west of Theta Virginis. The planet is stationary in right ascension on June 27th, resuming eastward motion thereafter. The February issue contains a map of Neptune's path.

E. O.

DEEP-SKY WONDERS

On the borderline between the great spiral nebula beds of Virgo and the profusion of galactic objects around the Ophiuchus-Scorpius-Sagittarius region, lies the magnificent and somewhat neglected globular cluster Messier 5, NGC 5904. Formerly it was included in an extension of Libra which curled up into Serpens, and consequently it is catalogued as a Libra object in the older observers' texts by Smyth, Chambers, Webb, and Serviss. Now, with the IAU revisions of the constellation boundaries, it is officially in Serpens.



The region of NGC 5904 (M5) with a scale of one centimeter to a degree. Stars 4, 5, and 6 Serpentis are labeled. The brightness is by magnitude intervals to magnitude 9. South is at the top.

M5 is the brightest globular cluster in the northern hemisphere of the sky, outshining even the famous M13, and indeed surpassed by only two southern globulars, 47 Tucanae and Omega Centauri. Smyth says:

"This superbe object is a noble mass, refreshing to the senses after searching for faint objects; with outliers in all directions, and a bright central blaze which even exceeds 3M in concentration."

While even binoculars will locate this massive cluster, increasing aperture resolves stars by the hundreds, until with 12-inch to 16-inch instruments it appears as one of the most compelling objects on record. It can easily be located about seven degrees to the southwest of Alpha Serpentis, just north of the star 5 Serpentis; its 1950 position is at right ascension $15^h\ 16^m.0$, declination +2° 16′.

WALTER SCOTT HOUSTON

Planetarium Notes

BALTIMORE: *Davis Planetarium.* **Maryland Academy of Sciences, Enoch Pratt Library Building, 400 Cathedral St., Baltimore 1, Md., Mulberry 2370.**

SCHEDULE: 4 p.m. Monday, Wednesday, and Friday; Thursday evenings, 7:45, 8:30, 9:30 p.m. Admission free. Spitz projector. Director, Paul S. Watson.

BOSTON: *Little Planetarium.* Boston Museum of Science, Science Park, Boston 15, Mass. Richmond 2-1410.

SCHEDULE: Tuesday thru Friday at 3:30 p.m.; Saturday, 2:00 and 3:30 p.m.; Sunday, 3 and 4 p.m. Spitz projector. In charge, Charles A. Federer, Jr.

BUFFALO: *Buffalo Museum of Science Planetarium.* Humboldt Parkway, Buffalo, N. Y., GR-4100.

SCHEDULE: Sundays, 2:00 to 5:30 p.m. Admission free. Spitz projector. For special lectures address Elsworth Jaeger, director of education.

CHAPEL HILL: *Morehead Planetarium.* University of North Carolina, Chapel Hill, N.C.

SCHEDULE: Daily at 8:30 p.m.; Saturday and Sunday at 3:00 p.m. Zeiss projector. Director, Roy K. Marshall.

CHICAGO: *Adler Planetarium.* 900 E. Achsah Bond Drive, Chicago 5, Ill., Wabash 1428.

SCHEDULE: Mondays through Saturdays, 11 a.m. and 3 p.m.; Sundays, 2:30 and 3:30 p.m. Zeiss projector. Director, Wagner Schlesinger.

LOS ANGELES: *Griffith Observatory and Planetarium.* Griffith Park, P.O. Box 9787, Los Feliz Station, Los Angeles 27, Calif., Olympia 1191.

SCHEDULE: Wednesday and Thursday at 8:30 p.m. Friday, Saturday, and Sunday at 3 and 8:30 p.m.; extra show on Sunday at 4:15 p.m. Zeiss projector. Director, Dinsmore Alter.

NEW YORK CITY: *Hayden Planetarium.* 81st St. and Central Park West, New York 24, N. Y., Endicott 2-8500.

SCHEDULE: Mondays through Fridays, 2, 3:30, and 8:30 p.m.; Saturdays, 11 a.m., 2, 3, 4, 5, and 8:30 p.m.; Sundays and holidays, 2, 3, 4, 5, and 8:30 p.m.; Wednesdays and Fridays, 11 a.m., for school groups. Zeiss projector. Curator, Gordon A. Atwater.

PHILADELPHIA: *Fels Planetarium.* Franklin Institute, 20th St. at Benjamin Franklin Parkway, Philadelphia 3, Pa., Locust 4-3600.

SCHEDULE: Tuesdays through Sundays, 3 p.m.; Saturdays, 11 a.m.; Saturdays, Sundays, and holidays, 2 p.m.; Wednesdays, Fridays, and Saturdays, 8:30 p.m. Zeiss projector. Director, I. M. Levitt.

PITTSBURGH: *Buhl Planetarium and Institute of Popular Science.* Federal and West Ohio Sts., Pittsburgh 12, Pa., Fairfax 4300.

SCHEDULE: Mondays through Saturdays, 2:15 and 8:30 p.m.; Sundays and holidays, 2:15, 3:15 and 8:30 p.m. Zeiss projector. Director, Arthur L. Draper.

SPRINGFIELD, MASS.: *Seymour Planetarium.* Museum of Natural History, Springfield 5, Mass.

SCHEDULE: Tuesdays, Thursdays, and Saturdays at 3 p.m.; Tuesday evenings at 8 p.m.; special star stories for children on Saturdays at 2 p.m. Admission free. Korkosz projector. Director, Frank D. Korkosz.

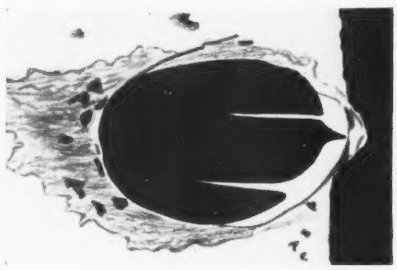
STAMFORD: *Stamford Museum Planetarium.* Courtland Park, Stamford, Conn.

SCHEDULE: Sunday, 4:15 p.m. Special showings on request. Admission free. Spitz projector. Director, Robert E. Cox.

MORE ON PLATO

Since my pen sketch of the lunar crater Plato was published in the February issue of **Sky and Telescope,** a scattering of cards and letters has come in from all points of the compass. One particularly interesting communication came from G. Persson, 41 Sallingvej, Copenhagen F., Denmark.

Mr. Persson's own drawing of Plato herewith appears, and he writes that these "tongues of light" are best seen one day after first quarter; further, that they can be seen for only a two-hour period (Klein), and even then they are not to be picked up at every lunation. I must confess that, although I have observed Hevelius' greater black lake many times, I have never witnessed these streaks in Plato's morning.



A drawing of the lunar formation Plato, by G. Persson on May 9, 1946, at 19:43 UT, with a 160-mm. Cassegrainian, 65 power.

JULIAN WALLACE GRAHAM
P. O. Box 764, Salem, Ore.

MOON PHASES AND DISTANCE

Last quarter	June 7, 11:35
New moon	June 15, 15:53
First quarter	June 23, 5:12
Full moon	June 29, 19:58
Last quarter	July 7, 2:53

	June	Distance	Diameter
Apogee	12d 6h	252,200 miles	29′ 26″
Perigee	27d 21h	224,900 miles	33′ 00″
	July		
Apogee	9d 21h	251,600 miles	29′ 31″

LUNAR ECLIPSE OBSERVED

The total lunar eclipse of April 2-3 was observed here despite rain earlier in the night. Throughout totality and earlier the darkest part of the moon was in the north in the region of Mare Frigoris. Although the maria and the rim continued to be distinctly visible, the darkening of the disk was sufficiently pronounced to cause the usual blood red or rusty hue to be faint. The play of light on the illuminated crescent around the western and southern edges was a conspicuous feature.

Looking at the moon and Mars in the field of a binocular reversed (the object glass placed at the eye), I found it difficult to estimate their difference in magnitude during totality, but it was well over five magnitudes.

A. T. G. BRITO
Y.M.C.A., Colombo 1
Ceylon

Ed. Note: Mr. Brito's report included the summary published here. His complete account is being forwarded to the Association of Lunar and Planetary Observers.

PREDICTIONS OF BRIGHT ASTEROID POSITIONS

No. 15	**Eumonia**		Mag. 8.5	
	h	m	°	′
June 18	20	7.8	−22	17
28	20	0.8	−21	58
July 8	19	51.6	−21	39
18	19	41.1	−21	18
28	19	30.6	−20	55
Aug. 7	19	21.3	−20	30
No. 7	**Iris**		Mag. 8.9	
	h	m	°	′
June 8	19	02.1	−20	32
18	18	53.7	−20	21
28	18	43.5	−20	10
July 8	18	32.7	−20	00
18	18	22.3	−19	50
28	18	13.6	−19	42
No. 25	**Phocaea**		Mag. 9.0	
	h	m	°	′
June 18	19	39.6	+18	04
28	19	35.3	+20	44
July 8	19	28.9	+22	35
18	19	21.5	+23	26
28	19	14.8	+23	15
Aug. 7	19	10.0	+22	08
No. 419	**Aurelia**		Mag. 9.3	
	h	m	°	′
June 8	18	58.4	−17	44
18	18	52.8	−17	13
28	18	45.2	−16	52
July 8	18	37.0	−16	40
18	18	29.8	−16	36
28	18	25.4	−16	39
No. 68	**Leto**		Mag. 9.6	
	h	m	°	′
July 8	20	50.0	−31	04
18	20	42.5	−32	04
28	20	33.3	−32	52
Aug. 7	20	23.8	−33	23
17	20	15.3	−33	33
27	20	09.0	−33	21
No. 17	**Thetis**		Mag. 9.6	
	h	m	°	′
July 28	22	17.2	−13	14
Aug. 7	22	10.5	−14	28
17	22	02.1	−15	46
27	21	53.4	−17	00
Sept. 6	21	45.8	−18	01
16	21	40.4	−18	42

The above are predicted positions in right ascension and declination for the epoch 1950.0, for 0h Universal time. The magnitude is that expected at opposition. In each case the motion of the asteroid is retrograde.

The sky as seen ′rom latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of June, respectively.

STARS FOR JUNE

ON THE stereographic projection of this chart, the declination circles have varying sizes, and their centers are not at the pole (as they are in the sky). For the circumpolar region from +40° to the pole, each declination circle crosses the meridian twice, and its center is midway between the two points of crossing.

It is easily seen that the declination circle centers all lie **above** the pole. The circles for declinations farther south than +40° become larger and larger. Three points of each of these circles are marked: one on the meridian, one on each side of the 40° horizon (except where a chart feature interferes), and their centers are on the extension of the meridian at the top of the chart and even far off the top of the page. The radius of the −40° circle is infinity, thus this circle is a straight line. The southern chart projection is similar, except that in that case the basic latitude is −30°.

Last month it was mentioned that no change in the scale of declination takes place in the sky itself. On the flat surface of the chart, however, the scale does change, for the circles of declination get farther apart with increasing distance from the zenith, whether north-south or east-west directions are considered.